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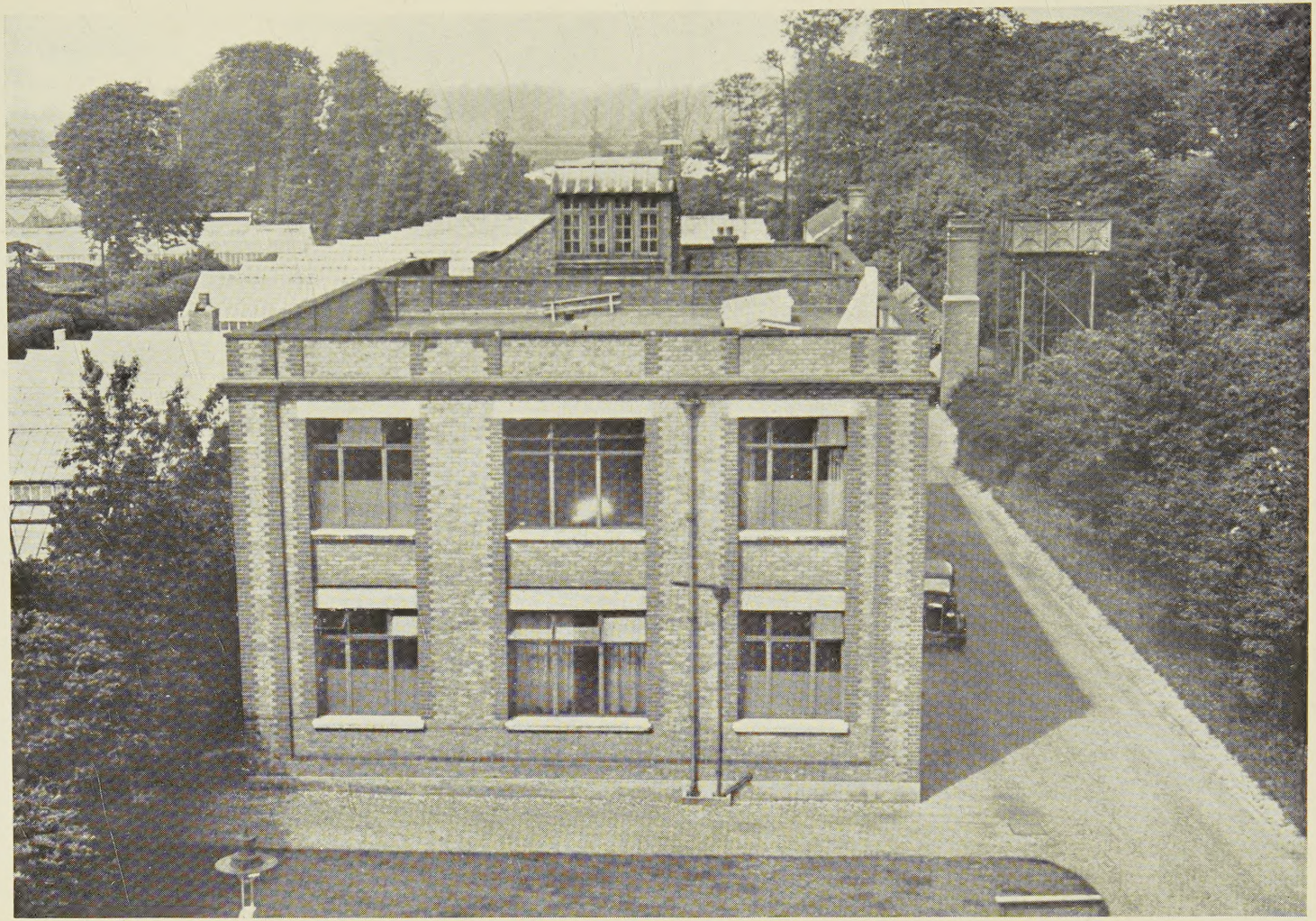

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INTRODUCTION

THE year 1946, being part of the transition period between war and peace, has little to recommend it. Crops throughout the country were perhaps above the average, but growers' difficulties with labour and supplies seemed to increase rather than decrease. The work of the Research Station made steady progress, and we look forward to greater facilities for research, particularly with flowering plants, as the National Agricultural Advisory Service gets into its stride.

Current Investigations

The investigations started in 1940 to examine the relative effects of sulphate and muriate of potash on the tomato will be discontinued in future. The results of 1946 confirm previous results, which are now summarised.

As this year marked the beginning of a general recovery to normal conditions, most of the experiments were concerned with the question of varieties in an attempt to determine which are most likely to suit conditions of peace.

In the case of cucumbers, the first crop since 1939, eight varieties were tested but none proved more suitable than the old favourites, Butcher's Disease Resister and Rochford's Market.

The cultivation of tomatoes and carnations in gravel and sand cultures was continued and will be extended in 1947.

Lettuce trials included the latest strains of Cheshunt 5A and Cheshunt 5B, hybrids between Cheshunt Early Giant and Green Frame.

The mushroom experiments discontinued during the War were started again, an attempt being made to prepare straw compost that would compare favourably with composted horse manure. These first attempts were unsuccessful.

The investigation of *Verticillium* Wilt of the tomato and cucumber has been continued. This year tomatoes were grown in the border instead of in 9-in. pots as in previous years. It was again found that the disease caused by *Verticillium albo-atrum* was less severe under warm, moist conditions than under normal conditions of temperature and atmospheric humidity, but that caused by *V. dahliæ* was not affected.

It was confirmed that high soil moisture did not materially affect the severity of attack by either species.

Tomatoes growing in the deficiency plots in House 4 were inoculated with both species of *Verticillium*. Wilt due to *V. albo-atrum* developed most rapidly in plot 8 (Complete Artificials + Stable Manure), but was most severe in plot 3 (Complete Artificials) where the plants began to wilt slightly later than in plot 8. The severity of the symptoms was similar in the three plots from which nitrogen, phosphate and potash had been withheld for many years, but in the last case it was less than in the previous two plots. In the unmanured plot it was intermediate between these two groups of plots. Wilting caused by *V. dahliae* was slight in all plots.

Treatment of the soil with 8-hydroxyquinoline sulphate did not prevent the development of the wilts caused by *V. albo-atrum*, *V. dahliæ*, and *Fusarium bulbigenum var. lycopersici*.

In experiments with cucumbers, infection with *V. albo-atrum* was readily obtained. The disease was less severe in the summer than in the autumn. Only a small proportion of the plants inoculated with *V. dahliæ* became infected. No external symptoms were observed, but the presence of the fungus in the lower part of the stem was proved by isolating it from the tissues. It appears improbable that *V. dahliæ* is of any importance as a cause of wilt under commercial conditions.

A species of *Pythium* has been isolated from *Primula obconica* plants which were wilting and dying just before flowering. It caused a rot of the tissues when inoculated through wounds, but plants grown in infected soil remained healthy. It seems probable, therefore, that some cultural condition was the primary cause of the disease.

Young tomato plants suffering from a form of foot rot have occasionally been received from growers. In these plants the pith is usually rotted and the cavity filled with the mycelium of a species of *Pythium*. The organism has been isolated in pure culture and the disease reproduced by

inoculation. The fungus can also cause slight damping off of seedlings in boxes. It resembles *P. debaryanum*, which is one of the common causes of damping-off of seedlings. Its morphology, together with that of the fungus from *Primula obconica* and others isolated from Japanese Rape and cucumber fruit, is still under investigation.

Investigation of the stem rot of tomatoes caused by *Didymella lycopersici* has been continued. Further spore trapping experiments have shown spores to be present in the open air in the early months of the year when the glasshouses are empty.

Ethyl mercuric phosphate was found to be an effective fungicide for soil treatment before planting out and could be used after planting at concentrations which rendered the soil surface toxic to spores without injuring tomato plants.

Ethyl mercuric phosphate at a concentration of 1 : 25,000 was more effective against *Didymella* when used as a spray than Shirlan A.G. 1 : 50. No control of existing infections was obtained. Tomato fruits were not tainted by the use of ethyl mercuric phosphate.

Didymella was found to penetrate to a depth of 3 ins. in culture tubes of sterilised soil, but only to a depth of ½ in. in unsterilised soil.

Glucose added to infected soil greatly increased the numbers of infected plants growing in the soil. The growth rate of the fungus in pure culture on media containing starch and a number of sugars was determined. No significant differences were obtained.

The influence of soil conditions on the susceptibility of the tomato plant to mosaic inducing viruses has been investigated further. It has been found possible to produce a well-developed plant showing relatively high resistance to infection following leaf-inoculation with Tobacco Mosaic Virus. An unusual symptom picture associated with the presence of Spotted Wilt virus on a commercial crop was investigated. Experiments with fruiting plants have shown that, in a fast-growing plant, light infection with a virus of the Tobacco Mosaic type may result in localisation of virus in the developing fruit and spreading to the young leaves may be very slow.

Some preliminary observations upon the effect of azobenzene on Red Spider-mite have been carried out. Results show that good control of this pest can be obtained on some plants by a number of methods of fumigation with azobenzene. It would appear that initial high concentration of the vapour in the atmosphere produced a strongly irritant action, reminiscent of that caused by the vapour of naphthalene. When subjected to low concentrations, or after having been placed in contact with small amounts of the compound in a semi-solid state, the mites became lethargic and many remained in a comatose condition for at least six days before they succumbed.

It has been shown that a high mortality may occur within a period of two or three days amongst recently-emerged White Flies when they are kept upon tomato leaves which have been cut from the plants, even if the stalks are immersed in water.

In spraying experiments upon tomato plants infested by White Fly a suspension of D.D.T. used at a concentration of 1 : 2,000 was much more destructive to the "scale" stages up to the third instar than an emulsion used at a concentration of 1 : 1,000; the eggs and pupæ (fourth instar) in a more advanced state of development were not killed at these concentrations. The adult flies were killed by both suspension and emulsion at a concentration of 1 : 4,000. At this dilution the lethal action appeared to persist upon the sprayed foliage for a period of about 12 days; and in the case of the more concentrated sprays ceased within a period of three weeks after application.

Rhubarb grown amongst tomato plants did not prevent the development of a severe infestation.

In experiments upon the Cucumber-house Woodlouse, the lethal action of D.D.T. as a 5 per cent. dust, and when mixed with soil at the rate of one part pure D.D.T. to 100 parts soil, was uncertain. When used in poison baits, D.D.T. killed the woodlice at a slower rate than Paris green: a mixture of one part D.D.T. with 100 parts dried blood was inferior to a mixture of one part Paris green and 56 parts dried blood.

Lloyd's observations on the Tomato Moth in 1920 showed that only a very small proportion of caterpillars were able to complete their development if fed upon an unvaried diet of Tomato foliage (variety Comet). Observations recorded during recent years and particularly in July, 1946, upon caterpillars collected from the Cheshunt Experimental Station glasshouses, suggest that through the action of selection, a race of the insect has become established, the caterpillars of which develop normally when fed exclusively upon the foliage of the old variety Comet and of more recently-introduced varieties.

In connection with the injury caused to the cotyledons of tomato seedlings by the larvæ of the Tomato Leaf Miner and with the practice, adopted by some growers, of removing the cotyledons as a means of control, experiments were carried out to determine the effects upon subsequent growth of the plants after the cotyledons had been removed at progressive intervals of time after germination of the seed. From the results obtained, there are indications that cotyledons cannot be

removed without risk of retardation in growth, as measured by height and leaf-span, until a minimum of 14 days has elapsed after the seed has germinated.

A good measure of control of the root eelworm (*Heterodera marioni*) was obtained by injecting D.D. mixture (*dichloropropane* and *dichloropropene*) into eelworm infested soil.

The residual effects following the addition of sulphur and sulphuric acid to tomato soil for the 1945 crop have been studied. During the 1945–46 winter, soil dressed with sulphur at the rate of 2 tons per acre had pH values between 7·14 and 7·0. During the 1946 season the value fluctuated and at one time reached a peak of 7·76, but by the end of December it had fallen to 7·17. Over the same period the carbonate value changed little, being 1·5 per cent. in January and 1·6 in December. In other words, the heavy dressing of sulphur had effected a permanent reduction in both pH and carbonate values. The addition of sulphuric acid equivalent to 10 cwts. of sulphur per acre had a less-permanent effect and during the year the carbonate increased from 1·5 per cent. to 2·0 and the pH value from 7·0 to 7·26.

Betanaphthoxyacetic acid has been used with beneficial effect on the setting of tomato fruits on commercial nurseries. The early promise of alpha-2 : 4-dichlorophenoxy-propionic acid has not been realised in practice. 2 : 3 : 5 tri-iodobenzoic acid has been suggested as a soil dressing to induce flowering and flower trusses instead of vegetative shoots, but we have been unable to reproduce the results claimed for this compound.

Mild injury to young tomato plants in pots on a commercial nursery, attributed to volatile compounds generated from "green" oak or chestnut staging, has been found to be unconnected with the wood.

Deficiency experiments have been continued and extended to carnations. On these plants acute deficiencies of calcium, phosphorus, potassium, and nitrogen are earliest in their effects. During the season deficiencies of magnesium and potassium respectively on chrysanthemums on commercial nurseries have been observed for the first time.

Work on the relative merits of the different extractants for the estimation of "available" soil potash and phosphate have been continued and extended to actual uptake of these nutrients by plants.

Experiments regarding the rates at which some organic nitrogenous fertilisers generate nitrate have commenced. So far the work has been confined to one particular soil. Under the conditions of the experiments all the fertilisers used, except hoof meal and hoof and horn, show a high rate of nitrate production in the first five days after mixing with soil, after which there is a much slower production of nitrate which continues for some 60–70 days. Hoof meal and hoof and horn, however, showed a loss of nitrate during the first five days but a positive production thereafter. The outstanding feature of the results to date is that, except for guano, curves showing nitrate accumulation follow one another and the amounts of nitrate produced from equal quantities of nitrogen are not so divergent as might be expected. Guano, however, produced considerably more nitrate than any other material in the first five days and the nitrate content remained at a consistently higher level, throughout the experiments. An unexpected result was that shown by bone meal, which produced a higher nitrate value in the first five days than all others except guano. Indications were obtained that the phosphate content may contribute to this result. Another interesting result is that for all the fertilisers the addition of comparatively little water reduces nitrate levels. This confirms a conclusion drawn from earlier work here, namely that mere wetting of the soil so that no leaching occurs causes disappearance of nitrate.

I. DIRECTOR'S REPORT OF THE EXPERIMENTAL RESULTS OF 1946

1. TOMATOES

The practice of grading the tomato fruits from the experimental plots adopted in 1921 was continued:—

A. "Pinks" number 5 to 7 and "Pink and White" 8 to 10 to the lb. These are the best quality of fruit in size, shape, and colour; "Pinks" being slightly larger than "Pink and Whites."
B. "Whites." These fruits are of good colour but smaller than "Pink and Whites."
C. "Blues." This grade consists of fruits of good colour but larger and more irregular in shape than Grade A.
D. "Roughs." Small mis-shapen fruits about the size of cherries.
E. Blotchy fruits which ripen irregularly.
F. Fruits showing Blossom End Rot.
G. Fruits showing the lesions of Stripe Disease.
H. Fruits showing "Green Back."

(a) Houses 7–9 : Sulphate of Potash versus Muriate of Potash

This experiment has now lasted seven years, and as no useful purpose can be served by continuing it this will be its final year.

Results of the 1946 experiments are given in Table 1 and a summary of the seven years' results in Table 2. The manurial treatment appears in Table 3. So far as the two varieties E.S.1 and Potentate are concerned, it can be said that E.S.1 tolerates chloride of potash more than Potentate. Indeed the quantity applied during the course of the experiment had practically no effect upon E.S.1.

TABLE I

VARIETIES: HOUSE 7, POTENTATE. HOUSE 8, E.S.1. HOUSE 9, E.S.5.

House	Plot	Treatment	Crop Yield in Lbs. per Plant						Total Tons per Acre	Average Tons per Acre	% Blotchy Ripening
			June	July	Aug.	Sept.	Oct.	Total			
7	1	Sulphate of Potash	1·67	3·78	2·13	1·48	0·39	9·45	71·82		10·78
7	3	,, ,,	0·91	3·46	1·77	1·20	0·24	7·58	57·60		6·46
8	2	,, ,,	0·88	3·04	1·78	1·07	0·22	6·99	53·12	58·04	0·57
8	4	,, ,,	0·87	2·94	2·07	1·16	0·41	7·45	56·62		0·94
9	3	,, ,,	0·48	3·02	2·22	1·55	0·28	7·55	57·39		0·53
9	4	,, ,,	0·71	2·83	1·88	1·12	0·26	6·80	51·67		0·59
7	2	Muriate of Potash	1·31	3·17	1·73	1·36	0·05	7·62	57·92		13·25
7	4	,, ,,	1·18	3·49	1·64	1·04	0·26	7·61	57·84		8·67
8	1	,, ,,	1·13	3·03	1·94	0·88	0·16	7·14	54·27	53·94	0·70
8	3	,, ,,	0·75	2·94	1·76	0·85	0·12	6·42	48·78		1·87
9	1	,, ,,	0·82	2·93	1·90	1·16	0·28	7·09	53·88		1·27
9	2	,, ,,	0·59	2·88	1·81	1·30	0·12	6·70	50·93		0·89

TABLE II

CROP YIELD IN TONS PER ACRE

Year	Sulphate of Potash			Muriate of Potash		
	Ailsa Craig	E.S.1	Potentate	Ailsa Craig	E.S.1	Potentate
1940	54·46	49·20	—	48·76	45·72	—
1941	—	47·21	43·47	—	45·89	42·45
1942	—	65·98	76·36	—	64·87	72·57
1943	—	52·40	50·33	—	50·46	49·82
1944*	—	28·04	42·10	—	27·18	39·48
1945	—	53·54	65·51	—	58·04	63·10
1946	—	54·03	59·79	—	52·41	54·70
Average excluding 1940 & 1944		54·63	59·09		54·33	56·53

* Weight for June and July only is given owing to air-raid destruction in July.

TABLE III

Manurail Treatment in Houses 7, 8 & 9

SULPHATE OF POTASH SERIES

(i) *Applied before planting*

Hoof and horn	...	10 cwts.	per acre.
Bone Meal ...	...	10 „	
Sulphate of Potash	...	10 „	

(ii) *Top dressing*

A first top dressing of 5 cwts. sulphate of potash per acre applied with the first watering; followed by dressings of a mixture containing 10 per cent. potash as sulphate of potash every 14 days at discretion, applied at the rate of 5 cwts. per acre.

Muriate of Potash

Application similar to the above but with muriate of potash in equivalent amounts instead of sulphate of potash.

In the case of Potentate there was a distinct reaction of chloride just at a time when the content in the soil was at a maximum. This coincided with the commencement of picking, by which time the plants had assumed a yellowish appearance. Later, as picking proceeded and the chloride content of the soil was reduced by ordinary watering, the plants gradually recovered their normal green colour. The variation in reaction to soil chloride between E.S.1 and Potentate is reflected slightly in crop yield as can be seen in Table 2.

The conclusion to be drawn from these experiments is that, under our conditions, sulphate of potash can be replaced by muriate of potash in time of necessity, but we are careful to point out that where the soil or the water supply is richer in chlorides than ours muriate of potash may be injurious.

(b) Variety Trials

As we are starting what seems to be a new era, following the end of hostilities, it was thought that most of the experiments this year should be concerned with the testing of varieties to select those that will be more suitable for future conditions than those used during the War.

House 1 was used for an experiment with the latest selections of Leaf Mould Resister No. 1. In the past this variety seemed to give best results when grown in poor soil under cool conditions. As the soil in this house had been steamed thoroughly during the winter, it was decided to plant two plots in the ground and two plots in 9-in. pots stood on the ground, to determine the effect of root restriction during the early stages of growth of this variety.

Rather earlier picking occurred in the pots and the quality of the fruit was better, but the monthly and total figures given in Table 4, show that crop production varied little between the two series. It seems evident that continued selection has produced a variety which is more suitable for ordinary cultivation than the original. Throughout the whole season the plants remained highly resistant to attack by *Cladosporium fulvum*.

House 3 was planted with eight varieties in duplicate plots, but unfortunately a leaky roof, due to previous war damage, upset the crop so badly that any attempt at comparison between the varieties would be unfair. All that can be said is that Duffern's seedling, which is a Sunrise type, showed up well and yielded 56·96 tons per acre.

In house 10 the varieties Commander, Democrat, and Perfection were compared with E.S.5, a greatly improved selection raised from some old seed of Cooper's Ideal at the beginning of the War. The results are given in Table 5. Under prevailing conditions all four varieties were of a similar type and will be re-examined in 1947. They cropped well as the figures indicate, and the quality of the fruit was good.

In part of house 2, Vetomold and V121, resistant to *C. fulvum*, were grown. The crop figures are given in Table 5.

In houses 11 and 12, E.S.1, E.S.4, Ailsa Craig, Down's seedling and Vanguard were grown. The results are given in Table 6. The crop yields were heavy, and the quality of the fruit was good except in the case of E.S.4, which seems to have reverted to the Kondine type. If this deterioration is repeated in 1947, the variety will be discarded. Down's seedling, another Sunrise type, was particularly noteworthy.

TABLE IV

VARIETY: LEAF MOULD RESISTER No. 1 (L.M.R.1)

House	Plot	Treatment	Crop Weight in Lbs. per Plant						Total Tons per Acre	Average Tons per Acre	% Blotchy Fruit
			June	July	Aug.	Sept.	Oct.	Total			
1	1	Planted in 9-in. pots, standing on the ground ...	0·63	1·35	1·94	1·17	1·19	6·28	47·12	46·17	0·17
	3	" " "	0·55	1·59	1·70	0·88	1·25	5·95	45·22		0·50
1	2	Planted in the ground ...	0·14	2·79	1·68	1·04	0·90	6·55	49·78	46·97	0·61
	4	" " " ...	0·55	1·80	1·87	0·86	0·73	5·81	44·16		7·61

TABLE V

VARIETY TRIALS

House	Plot	Variety	Crop Weight in Lbs. per Plant						Total Tons per Acre	% Blotchy Ripening
			June	July	Aug.	Sept.	Oct.	Total		
10	1	Commander ...	0·66	2·92	2·35	1·62	0·34	7·89	59·97	0·76
	2	Democrat	0·16	2·81	2·23	2·20	0·43	7·83	59·51	0·77
	3	E.S.5	0·75	3·44	2·21	1·57	0·45	8·43	63·99	0·47
	4	Perfection	0·99	3·25	2·20	1·17	0·29	7·90	60·04	0·13
2	1	V 121	1·61	2·91	1·74	0·63	0·21	7·10	53·96	4·61
	2	Vetomold	1·44	2·72	1·77	0·39	0·24	6·56	49·86	4·96

TABLE VI

VARIETY TRIALS

House	Plot	Variety	Crop Yield in Lbs. per Plant							Total Tons per Acre	Average Tons per Acre	% Blotchy Fruit
			June	July	Aug.	Sept.	Oct.	Nov.	Total			
11	1	E.S.4	0·78	2·95	2·38	2·00	0·84	0·44	9·39	71·35	72·08	2·87
12	3	E.S.4	0·91	2·80	2·47	2·40	0·75	0·25	9·58	72·81		1·36
11	2	Ailsa Craig ...	0·74	2·58	2·78	2·28	0·59	0·31	9·28	70·53	69·80	1·94
12	1	" " ...	0·53	3·41	2·16	1·87	0·78	0·34	9·09	69·07		0·55
11	3	E.S.1	0·66	3·19	2·47	2·14	0·66	0·31	9·43	71·66	72·73	2·01
12	4	"	1·00	3·18	2·57	2·12	0·71	0·13	9·71	73·79		0·21
11	4	Down's Seedling	0·27	3·11	2·23	2·14	0·90	0·32	8·97	68·16		2·11
12	2	Vanguard ...	1·04	2·34	2·44	2·58	0·89	0·35	9·64	73·27		1·87

TABLE VII

Seedlings from Potentate

House	Plot	Variety	Crop Weight in Lbs. per Plant							Tons per Acre	% Blotchy Ripening
			May	June	July	Aug.	Sept.	Oct.	Total		
5	1	Seedling A ...	0·02	2·09	2·76	1·23	0·49	0·05	6·64	50·46	1·3
	2	,, B ...	0·02	1·99	2·59	0·99	0·46	0·04	6·09	46·28	2·4
	3	,, C ...	0·02	2·04	3·18	0·89	0·53	0·06	6·72	51·08	6·1
	4	,, D ...	0·01	1·90	3·06	1·39	0·60	0·08	7·04	53·52	6·4

TABLE VIII

Cucumbers : Varieties

House	Plot	Variety	Crop Yield in Lbs. per Plant								Total Tons per Acre	Average Tons per Acre
			April	May	June	July	Aug.	Sept.	Oct.	Total		
D	1	Butcher's "Disease Resister"	9·50	18·50	7·84	9·83	6·75	6·04	0·70	57·16	95·74	85·48
E	3	,, ,, ,,	9·01	16·30	9·33	8·35	7·71	6·88	1·01	58·59	87·88	
F	4	,, ,, ,,	9·38	16·89	9·32	7·60	5·22	6·30	0·50	55·21	82·81	
D	4	Rochford's Market ...	7·80	13·48	10·93	8·70	7·16	6·86	0·74	55·67	83·50	87·30
F	3	,, ,, ...	8·27	14·99	10·51	9·42	7·86	8·40	1·28	60·73	91·09	
D	3	Telegraph	7·44	11·74	11·49	10·74	7·00	8·50	1·42	58·33	87·49	81·26
F	1	,, ...	7·60	13·42	10·99	7·30	5·34	4·82	0·75	50·02	75·03	
D	5	Chennel's Challenger ...	6·44	13·69	7·42	8·86	6·35	4·76	1·48	49·00	73·50	77·24
F	2	,, ,, ...	6·48	15·85	10·88	7·61	5·59	6·47	1·10	53·98	80·97	
D	6	Lockies' Perfection ...	8·89	13·48	8·50	8·89	7·05	4·22	0·30	51·33	76·99	79·92
E	4	,, ,, ...	10·37	14·74	7·88	8·01	4·96	4·67	0·60	51·23	82·84	
E	2	Every Day	7·77	13·29	11·18	7·74	6·87	6·21	0·82	53·88	80·82	
E	1	Tender & True	5·73	11·40	5·37	5·54	5·48	4·10	0·20	37·82	56·71	
D	2	De B. Hovell's Selection ...	10·62	14·62	8·88	9·57	7·66	10·35	1·64	63·34	95·01	

House 5 was devoted to the cultivation of four seedlings, which appeared in Potentate in 1945. Seedlings C and D resembled Potentate but were much more vigorous and lasting in habit. Seedling A was a new type with Sunrise characteristics and seemed fairly well fixed. Seedling B was a mixture of seedling A with several Potentate types.

The yields are given in Table 7. Seedling D showed no improvement over the best strains of Potentate, but several very good plants appeared in C from which seeds were taken for future use. Seedling B was discarded owing to its mixed nature and seedling A is being studied further under the name E.S.6.

2. CUCUMBERS

At the outbreak of war it was decided to cease the cucumber experiments and turn over to the cultivation of tomatoes in the cucumber houses. This proved to be a wise decision, for it led to the development of a new method of growing tomatoes in low narrow houses. This was the "roof crop" method which was adopted extensively throughout the country. (See Annual Report for 1942, pp. 22–24.)

As cucumber growers, however, are taking up the cultivation of this crop again, it was decided to restart the cucumber investigations this year by growing a number of different varieties under standard conditions. Houses D, E, and F only were used for this purpose, house G being set aside for the investigation of *Didymella* Stem Rot of the tomato.

The following varieties were selected for trial: Butcher's Disease Resister, Chennel's Challenger, Everyday, Lockie's Perfection, Rochford's Market, Telegraph, Tender and True and a selection received some years ago from the late Mr. de B. Hovell of Sussex.

The last of these is very interesting, for it was raised from a few very old seeds and seems to be an old type of Telegraph. It grew faster than the others in the early stages after planting out, and produced long, spiny but thin fruits rather dark in colour.

The results are given in Table 8. The old form of Telegraph gave the highest yield, being followed by Butcher's Disease Resister and Rochford's Market. Then came Telegraph and Lockie's Perfection, followed by the remaining three. These results generally are in keeping with commercial experience in the Lea Valley.

3. LETTUCE

(a) Cheshunt Early Giant and Cheshunt Early Ball

Cheshunt Early Giant, first distributed in 1933, still holds pride of place as the best lettuce for heated glasshouses during the autumn and winter months, and it was almost entirely due to this variety that the country was supplied with very large quantities of winter lettuce during the war period. Cheshunt Early Ball was distributed a year later and while it is not so well known as Cheshunt Early Giant it is popular with many growers. It received the First Prize at the Early Market Produce Show in 1935 and 1936, for Class 7—cabbage lettuces grown in unheated frames or under cloches but not on hot beds. These were the only occasions in which we competed. This variety is well worth the attention of growers for cold houses, cold frames, and cloches. It has one unusual characteristic, namely, it can be left in the frames uncut for six weeks after it is ready, and will not bolt.

(b) Lettuce 5a and 5b

In 1936 Cheshunt Early Giant was crossed with a selected strain of Green Frame, using Green Frame as the pollen-bearing parent. Twenty-two plants of different types were transferred to large pots and seeds taken successfully from 19 of them. Fourteen plants produced black and five white seeds. The mother plant, Cheshunt Early Giant, is white seeded and Green Frame black seeded.

In the F2 generation the black-seeded types produced plants all yielding black seeds, and the white-seeded types produced other white-seeded plants. After repeated trial only the white-seeded types were retained, the others being worthless.

In the F_2 generation two superior types of seedlings appeared, 5a and 5b. These were selected over a period of four years. At first they produced 3–5 per cent. of rogue plants, which grew very slowly and were small and distorted. The percentage of the rogues was gradually reduced, but not eliminated, in both seedlings. In 1941 small samples of seed were distributed to selected growers

for trial and in 1945 Messrs. D. T. Brown, of Poulton-le-Fylde, showed us a fine crop of 5a and 5b from which they had succeeded in eliminating the rogue plants. Working together in complete co-operation, which we valued considerably, greatly improved stocks of Cheshunt 5a and Cheshunt 5b have now been obtained. Unfortunately it has not yet been possible to grow sufficient seed for distribution and it is doubtful if much can be done while the present regulations for growing seed abroad are in force.

Cheshunt Early Giant, Cheshunt Early Ball, Cheshunt 5a and Cheshunt 5b are all cabbage lettuce of the Butter-Head type.

(c) Cheshunt Early Giant

This variety, given the correct treatment, will produce a large head 5 to 7 ounces in weight during the dark winter period. It is essentially a short-day variety, and is unsuitable for summer cultivation. The outer leaves during winter are bright green in colour, and very tender. During early spring when light intensity is higher, the colouring is usually a lighter green. Cultivation is most successful under temperatures around 50° F. Given a good rich soil and an abundance of water plants averaging 6 to 8 ounces each may be produced for the early spring crop. Repeated trials have proved it to be the only variety that will heart continuously during the darker winter period.

(d) Cheshunt Early Ball

This variety is a medium-sized lettuce when fully grown. The heart is solid and composed of very crisp tender leaves. Its average weight when fully matured is 5 to 6 ounces. The colouring is somewhat similar to Cheshunt Early Giant, a bright medium green, but it differs in the smaller amount of outer enveloping leaves. It has proved most suitable for cold frames and cloches, although its successful cultivation in cold houses is carried out by many growers.

One of its most valued qualities is the length of time from maturity to the formation of seed heads. Most varieties have a tendency to "bolt" when maturity is reached, but Cheshunt Early Ball can with all confidence be left in the frames or cloches for six weeks from the time cutting should commence to the time when the heart expands to allow the flowering shoot to emerge.

(e) 5A AND 5B.

These varieties still retain some of the characteristics of the original mother parent, Cheshunt Early Giant. They are, however, slightly smaller and more compact, and so a greater number can be grown to the acre. The colouring in the younger stages is a deeper and more vivid green, but this is to a large extent lost as development proceeds, although it is still a brighter green at maturity than Early Giant. Of an attractive appearance, it produces a somewhat rounded heart, similar to Green Frame, but the outer leaves have a tendency to grow more upright.

The average weight when fully matured is 5 to 6 ounces each. It is particularly suitable for growing in both steamed and very rich soil and is on an average one to two weeks earlier than Cheshunt Early Giant. Like Early Giant, it requires a slightly heated house, about 50° F. will suffice.

4. MUSHROOMS

The cultivation experiments with mushrooms started in 1936, when a mushroom shed fitted with shelves was erected. Half the cost was provided by the Ministry of Agriculture while the late Mr. J. Harnett presented the heating system and Mr. Ben Rubenstein the Western Red Cedar of which the shelves and their supports were constructed.

The first experiment started on April 6th, when prepared compost was taken into the shed. The investigations were discontinued in 1939 at the outbreak of war and were not resumed until the end of 1946.

At the commencement of this work, the investigations were concerned entirely with the question of "casing" soil. In 1936, second spit soil was obtained from Mr. J. Harnett's nursery at Hoddesdon, Mr. C. J. Horwood's nursery on Cheshunt Common, and from two nurseries in the West Sussex

area. All were heavy soils, the first two being brick earth and the second two heavy silts. All were practically free from organic matter. Mushrooms were picked first from the beds cased with soil from Cheshunt Common and six days later from the other three sections simultaneously. Sixteen days after picking commenced there was an outbreak of *Mycogyne* in six plots, all cased with the same soil. This was checked early by removing the infected clumps with a handful of compost, dusting the hole liberally with hydrated lime and then filling up with new soil contining 33 per cent. of lime. Later an outbreak of "truffle," *Pseudobalsamia microspora* started on beds cased with another soil and this spread to adjoining plots so rapidly that it affected the weight of crop and rendered any attempt at comparison between the different treatments quite useless. Incidentally, this was the first record of this disease in England.

These first experiments were most valuable, however, for they showed that mushroom diseases can be carried in casing soil and proved the wisdom of sterilising any soil used for casing.

In 1927 the problem of the casing soil was examined further. The soils used were as follows:—

(*a*) Research Station soil—a light loam moderately rich in organic matter.
(*b*) Nazeing Common soil—a light loam almost free from organic matter.
(*c*) Cheshunt Common soil—a heavy soil, rich in organic matter.
(*d*) Hoddesdon soil—a brick earth, heavy and free from organic matter.

All soils were sterilised by steaming at a temperature of 212° F., steam being passed into the soil for 30 minutes. The total yield was unusually high, probably because very good stallion manure was used for the beds and the spawn, Exhibition White made by the late Mr. J. Harnett, was exceptionally good. The Hoddesdon casing soil gave the highest average yield of 3·86 lbs. per square foot. The Research Station soil gave 3·45 and Cheshunt Common soil 3·42 lbs. per square foot, while Nazeing Common soil produced 3·16 lbs. per square foot.

There was little difference in the average weight of the mushrooms produced, but those on the Research Station and Cheshunt Common soils had longer stalks than those in the other two soils.

During 1937 small-scale experiments were arranged in which the beds were cased with the following: granite chips; stones; sand; peat; equal parts Research Station soil and stones; equal parts soil and sand; equal parts soil and peat; two parts soil and one part charcoal. Sand (1·48 lbs. per square foot), stones (1·8), peat (0·81), and granite chips (1·49) all gave a low yield, although the granite chips and stones produced very heavy mushrooms. Sand, stones, and peat respectively mixed with equal quantities of peat, all produced good mushrooms. The crop at the end of the first 10 days was 1·30 lbs. per square foot (peat and soil), 1·27 lbs. (stones and soil), and 0·65 lbs. (sand and soil). At the end of March these plots were recased, however, and the result was unsatisfactory. The habit of growth of the mushrooms in the above experiments was most unusual for the whole surface was covered with a solid mass of small, long-stalked mushrooms. The result, therefore, is of little interest commercially. It is valuable, however, because it shows that the growth of mushrooms is affected to a marked degree by the type of material used for casing the beds. The earliness of cropping and the increase in crop weight suggests the need for further investigation along these lines.

In a further experiment it was shown that white flake naphthalene and also sodium fluoride can be mixed with the manure immediately before making the beds without affecting the yield. The rate of application in each case was 3 lbs. per ton of manure.

In 1938 the casing soil experiments were continued, using various mixtures of soil, peat, and stones. Once again the addition of peat increased the yield appreciably, the average yield from the control beds, cased with soil only, being 1·55 lbs. per square foot and those cased with a mixture of two parts soil and one part peat produced 1·8 lbs. per square foot. Where stones were added to the extent of 33 per cent. the increase was slight and where the mixture contained both stones and peat the yield was unaffected.

The effect of mixing gypsum—28 lbs. per ton of manure at the first turning—was examined and in each case the crop yield fell when gypsum was omitted. The average yield was 1·02 lbs. per square foot where gypsum was omitted and 1·54 lbs. per square foot where it was added.

Reduction in crop has been traced occasionally to a type of secondary fermentation of the beds which gives rise to a sweet smell, resembling that of molasses, about five weeks after spawning. This suggests imperfect fermentation during the preparation of the compost, and an attempt was made to correct this by mixing cotton seed meal at the rate of 28 lbs. per ton of manure at the first turning. The results of these experiments were promising, the crop yields being increased from 1·5 lbs. per square foot in the control beds to 2·15 lbs. by the addition of cotton seed meal.

The question of temperature was also investigated. Air temperatures of 55°, 60°, and 65° F. were employed, and in an unheated chamber the bed temperature was maintained at 70° F. by

means of electrically-heated cables placed in the soil beneath. The results are given in the following table:—

Temperature of Air	Colour of Strain	Weight in Lbs. per Square Foot					
		January	February	March	April	Total	Average Total
65° F.	Brown	0·26	1·12	0·37	—	1·75	1·87
		0·32	1·19	0·37	0·10	1·98	
	White	0·03	0·96	0·22	0·01	1·31	1·39
		0·17	0·93	0·33	0·03	1·46	
60° F.	Brown	0·28	0·90	0·25	0·01	1·52	1·81
		0·35	1·23	0·43	0·09	2·10	
	White	0·23	0·70	0·23	0·02	1·18	1·45
		0·13	1·13	0·42	0·03	1·71	
55° F.	Brown	—	0·58	0·47	0·35	1·40	
	White	—	0·23	0·23	0·33	0·79	
Air not heated. Bed kept at 70° F. electrically.	Brown	0·16	0·82	0·37	0·09	1·44	
	White	0·22	0·38	0·12	0·01	0·73	

It will be seen that there was a reduction of crop at the lowest temperature 55° F., and little difference between 60° and 65° F. Incidently, the average size of the mushrooms was not affected by the different temperatures. The importance of the air temperature is seen in results at the bottom of the table, where, although the beds were maintained at a temperature of 70° F., there was a falling-off in yield due to the unheated atmosphere above the beds.

In a further experiment one bed 4 ins. deep was placed over electrically-heated cables laid in narrow troughs containing water, with the object of warming the beds and preventing them from drying out at the same time. The bed temperature was maintained at 75° F. constantly. As a control, a bed 4 ins. deep was placed over a layer of moist soil of the same depth. The results are given below:—

Treatment	Crop Yield in Lbs. per Square Foot					Average Total
	April	May	June	July	Total	
Control—4-in. Bed ...	1·20	0·80	0·24	0·10	2·34	1·61
	0·40	0·36	0·08	0·04	0·88	
Bed—4-in.—Warmed ...	1·52	0·56	0·04	—	2·12	2·20
	1·52	0·68	0·08	—	2·28	

These results are not convincing, but they show greater uniformity between the two warmed beds than between the controls. Further, the reduction of the depth of the composted manure from the standard 8 ins. to half this depth does not seem to have affected the yield appreciably.

Summarising the results of these experiments, several important points emerge.

(1) Mushroom diseases can be introduced in soil used for casing the beds, and for this reason it is advisable to sterilise all casing soil by means of heat.

(2) Thorough cleaning and sterilisation of the house, shelves, etc., between crops is an essential part of disease and pest control.

(3) Heavy clay or silt soils free from plant roots are the most suitable for casing purposes.

(4) In some cases the crop can be increased by mixing an appropriate amount of moist peat with the casing soil before application. 20 to 30 per cent. of peat is recommended for for trial purposes.

(5) The addition of gypsum to the manure at the first turning almost invariably increases the yield.

(6) The addition of cotton seedmeal –28 lbs. per ton of manure –at the first turning has increased the yield of mushrooms.

(7) Air temperatures of 60–65° F. are probably the optimum for mushroom cultivation.

II. PLANT DISEASES

I. GENERAL

By P. H. WILLIAMS and ENID SHEARD

The number of specimens received in the first nine months of the year totalled 385. This is approximately the same as in the same period of 1945. A number of interesting records were made during the year.

In early May, the tops of young tomato plants growing in frames were found to be dying. Examination revealed the presence of *Phytophthora parasitica*. The fungus had probably been splashed up from the soil during watering and had infected the plants owing to the favourable atmosphere in the frames.

A similar attack caused by *Phytophthora cryptogea* was observed in June when tomato plants growing in the open were found to be suffering from foot-rot caused by this fungus. A fortnight later the tops of plants in the same field were seen to be dead. The tissues were full of fungus mycelium which was identified later as *P. cryptogea*. The weather had been wet and stormy in the previous weeks and it seems probable that the fungus had been splashed up by rain on to the tops of the plants. The plants may also have been damaged by the wind thus rendering infection much easier.

Summer Savoury (*Satureia* sp.), suffering from a die-back caused by *Botrytis cinerea*, was brought to the laboratory in June. Again the disease was probably favoured by the wet weather.

Among other interesting records may be noted root-rot of Arum caused by *Corticium solani*.

An outbreak of Bacterial Blotch of mushroom (*Pseudomonas tolaasi*) occurred in a crop grown in a tunnel in a disused brickworks. The tunnel was not heated and the disease was doubtless favoured by the wet, cold conditions. Kligman and Penny have recorded outbreaks of a similar character in caves in Pennsylvania, but not in properly constructed mushroom houses. They also suggest that the bacterium may be spread by a saprophytic eelworm which is common in the overwet soil of the caves. In the outbreak here reported dusting with copper-lime dust and attention to ventilation controlled the disease.

Several specimens were received of cucumber plants and fruit suffering from Gummosis (*Cladosporium cucumerinum*), a disease which has become very uncommon during the past few years. Attention to hygiene and conditions of cultivation is the best method for avoiding this disease. If it does occur, the diseased fruit and leaves should be removed and burned and the plants sprayed with Colloidal Copper and White Oil Emulsion.

Reference

Kligman, A. M., and Penny, J. S. (1943). *Phytopathology* 33 : 1090–1093.

2. VERTICILLIUM WILT

By P. H. WILLIAMS

a. Tomatoes

(1) The Effect of Temperature on the Disease

In the pot experiments previously reported some difficulty was experienced in keeping the soil sufficiently wet after the plants had attained a certain size. Frequent watering led to leaching of nutrients and hence the correct balance of the plants could not be maintained. To overcome this difficulty this year the plants were grown in the soil.

The top spit of soil was removed from part of two chambers in a partitioned glasshouse and replaced with steamed soil containing stable manure. This was well flooded and subsequently sulphate of potash, bone meal, and hoof and horn were pricked in at the standard rate. Tomato plants were then set out in the borders, six plants in each chamber being inoculated with *Verticillium albo-atrum* and six with *V. dahliæ*. There were six uninoculated control plants in each chamber. The plants were inoculated by placing a piece of a petri dish culture of the appropriate fungus under the ball

of roots when planting. One chamber was ventilated normally while the other was kept closed as in the previous year's experiment. The plants were inoculated on April 29th.

The plants inoculated with *V. albo-atrum* showed the first signs of disease in the warm chamber on May 21st and in the normal chamber on May 23rd. Thereafter wilting became more severe, reaching a maximum in the warm chamber by May 30th and in the normal by June 4th. After June 7th the plants began to recover and all wilting had ceased in the warm chamber by June 19th and in the normal by June 27th. The average temperature for the period from April 29th to June 27th was 68·4° F. in the normal chamber and 73·3° F. in the warm chamber. The humidity for the same period averaged 70 per cent. in the normal chamber and 82 per cent. in the other.

The disease was again much less severe under warm moist conditions and recovery more rapid and complete. In one plant, only the lowest leaves wilted. In three others most of the leaves wilted occasionally, but the top of the plant remained turgid. Only in two out of the six did all the leaves wilt. In the normal chamber, on the other hand, all the leaves of five plants wilted while in the sixth the top remained turgid. The plants in this chamber were also very stunted and the top growth thin and weak. Recovery in all cases was permanent and the plants continued to grow until they were cut out on October 2nd.

The symptoms produced by *V. dahliæ* in plants growing in the soil were the same as those observed previously in pot plants. The lower leaves turned yellow and wilted and the plants were slightly stunted compared with the controls. The culture used for inoculations, however, did not appear to be so virulent as those previously employed for not all the plants became infected and disease symptoms were not so severe as in previous years.

Counts of dead and yellow leaves on infected plants were made five weeks after inoculation. 8·2 per cent. of the total number of leaves were affected in the warm chamber and 8·6 per cent. in the normal. There was thus little difference in the severity of the disease in the two chambers at that stage and none was noted later. None of the plants died as a result of infection with the disease.

(2) The Effect of Soil Moisture

Tomato plants, variety Potentate were grown in 9-in. pots and inoculated in the usual manner. Six were inoculated with *V. albo-atrum*, six with *V. dahliæ*, and there were four uninoculated controls. After inoculation, half the pots in each series were stood in pans of water and thereafter watered each day. The remainder were watered when necessary.

Of the plants inoculated with *V. albo-atrum*, those in the wet soil wilted one day before those receiving normal watering. The severity of the disease was slightly greater under wet conditions judged both from the degree of wilting and from counts of dead and yellow leaves. One plant in the normal series died six weeks after inoculation, but all the others recovered. From this experiment and that reported in the Annual Report for 1945, it has been concluded that high moisture content of the soil does not materially affect the course of the disease.

The results of inoculating tomato plants with *V. dahliæ* were inconclusive since all the plants did not become infected.

(3) The Effect of Manurial Treatment

Since 1917 certain plots in house 4 have received manurial treatments as follows:—

Plot 1—No nitrogen.
,, 2—Unmanured.
,, 3—Complete artificials.
,, 8— ,, ,, + stable manure.
,, 9—No phosphate.
,, 10—No potash.

One row in each plot (10 plants) was inoculated at planting time with *V. albo-atrum* and one with *V. dahliæ* by placing pieces of a culture under the ball of roots. Plots 8, 9, and 10 were inoculated on March 25th and the remainder on March 30th.

The first signs of disease in the plants inoculated with *V. albo-atrum* appeared between April 23rd and 25th. The disease was most severe in Plots 3 and 8. In these plots the topmost leaves of most of the plants wilted and two plants died in Plot 3 and three in Plot 8.

In Plot 1, 9, and 10 the disease was comparatively mild. Wilting in most cases only involved the lower leaves, the tops remaining turgid. One plant died in Plot 10. In the unmanured plot (No. 2) the reaction of the plants to the fungus was intermediate between that in Plots 3 and 8 and in Plots 1, 9, and 10.

It might be expected that the more vigorous growth in the plots receiving complete manurial treatments would make them less susceptible to the attack of the fungus. It may be, however, that the larger leaf area led to greater transpiration and also to more rapid movement of toxin in the plant. This might cause the wilt to be more severe.

The disease produced by *V. dahliæ* was slight and no difference could be detected between the plots.

(4) 8–hydroxy–quinoline Sulphate

It has been claimed that *Fusarium* Wilt of Carnations can be prevented by watering the beds with a solution of 8-hydroxy-quinoline sulphate. It was decided to try its effect on the tomato wilts caused by *Verticillium albo-atrum*, *V. dahliæ*, and *Fusarium bulbigenum* var. *lycopersici*.

The fungi were grown on sand containing 3 per cent. oatmeal and the cultures mixed with the potting soil three days before use. For each fungus enough inoculated soil was prepared to fill eight 9-in. pots. Immediately after planting, four pots of each series of eight were treated with ½-gallon of 1 in 1,000 solution of 8-hydroxy-quinoline sulphate. This treatment was repeated a fortnight later.

No differences were found in the severity of the diseases in the treated and untreated pots. Control plants growing in uninoculated soil were not injured by 8-hydroxy-quinoline sulphate at the strength employed.

b. Cucumbers

(1) V. albo–atrum

Cucumber plants variety Butcher's Disease Resister, growing in 9-in. pots were inoculated in the usual manner. The results were similar to those obtained last year.

In two experiments lasting from May 7th to June 26th, and from July 18th to August 22nd, the plants showed the typical wilting, yellowing and death of the leaves but were not stunted. The average temperatures in these experiments were 73° F. and 72° F. and the atmospheric humidity 72 per cent. and 84 per cent. In a later experiment lasting from October 23rd to December 12th the plants were severely stunted and three out of six died. The average temperature was 60° F. and the humidity 84 per cent. It is evident that the disease was favoured by the low temperatures.

(2) V. dahliae

In 1945 plants inoculated with *V. dahliæ* during the summer months remained healthy, but in the autumn a certain proportion showed disease symptoms. These plants were slightly stunted compared with the controls. It was not clear whether the positive inoculation results obtained in this experiment were due to the low temperature or to the use of a more virulent culture.

This year experiments have been carried out to elucidate this point.

In the first experiment, started on May 7th, the plants were inoculated with strain 69, a culture isolated in 1945. No external symptoms of disease were observed but *V. dahliæ* was isolated at cotyledon level from one plant.

In the second experiment, two strains of the fungus were used, No. 69 and No. 75, which had been recently isolated from tomato. The plants were inoculated on July 18th. No definite symptoms were observed and *Verticillium* was only re-isolated from one plant inoculated with Strain 75.

The experiment was repeated on October 23rd. Two plants became infected with Strain 69 and none with Strain 75. In one of the infected plants, the fungus was re-isolated from 6 ins. up the stem, in the other it was only found at cotyledon level. This experiment, therefore, gives some slight support to the view that *V. dahliæ* only travels up the plant when growth conditions are unfavourable.

The small proportion of plants which were infected by *V. dahliæ* suggests that the cucumber is highly resistant to this fungus and under normal commercial conditions it seems unlikely that it would cause serious disease.

3. SOME DISEASES CAUSED BY PYTHIUM SPP.

By P. H. WILLIAMS

(a) A Disease of Primula obconica

In November, 1944, *Primula obconica* plants which were wilting and dying just before coming into flower were received from Yorkshire. The crowns were rotting and a fungus was present in the

diseased tissue. Some of the petioles had collapsed but no fungus was seen in them and the collapse may have been secondary. The roots were healthy.

In the following year a few plants suffering from a similar disease were found among *P. obconica* plants on the Station Nursery. In this case the roots also were rotten.

From both lots of plants a fungus was isolated which appears to be a species of *Pythium*. The growth on oatmeal agar is luxuriant and reproductive bodies are abundant. The sporangia are spherical, either terminal or intercalary, 21·5 (17 to 27) μ in diameter. Oospores are also formed. Usually there is one antheridium but two have been seen occasionally. Work on the identity of the fungus is still in progress.

Petioles and flower stalks of a *Primula obconica* plant were inoculated with the fungus by inserting small pieces of a culture into wounds. After 16 days the petioles had collapsed but the flower stalks were unaffected. The fungus was successfully re-isolated from some of the petioles. The remainder were left on the plant, but the fungus did not grow back from them into the crown.

Attempts have been made to infect plants through the soil. In one experiment seedlings were potted up in compost with which cultures of the fungus on sand + 3 per cent. oatmeal had been mixed. They were potted into 5-in. pots when sufficiently grown. The plants all remained healthy over a period of 10 months.

In a second experiment, pieces of culture were inserted into the soil close to plants growing in 5-in. pots. Despite the injury done to the roots no infection resulted.

It would appear likely that some unfavourable cultural condition had predisposed the plant to infection. A similar disease of *Primula sinensis* has been described by Cook and Collins. *Pythium spinosum* was isolated from the roots but proved innocuous to plants growing in an open compost. It was considered that the compost in which the diseased plants had been grown was too dense for healthy root growth and that this predisposed the plants to infection. It is possible that in the case of the *P. obconica* disease, the soil of some of the pots was too tightly packed so that the plants were not able to root freely in it and that the fungus was able to attack these unhealthy plants.

(b) Foot Rot of Tomato

From time to time young tomato plants suffering from a form of foot rot have been received from growers. The plants were growing in 3-in. pots or had recently been planted in the borders. The symptoms resemble those caused by *Phytophthora* spp. but, on splitting the stem lengthwise, the pith is usually found to be rotted away and the cavity filled with the mycelium of a species of *Pythium*. In culture this fungus closely resembles *P. debaryanum*, the cause of damping-off in many plants.

The fungus was inoculated into the stems of young tomato plants and caused typical rot of the pith, the fungus being re-isolated. An attempt to reproduce the disease by potting plants in soil inoculated with the fungus was unsuccessful, probably because temperatures at the time (June) were too high.

Cultures of *Pythium* resembling that from the tomato have also been isolated from damped-off Japanese Rape seedlings and from rotted cucumber fruit.

The fungus from *Primula obconica* and also those from tomato, rape and cucumber fruit have proved capable of causing slight damping-off of tomato seedlings. Germination also was reduced. The results of two experiments are shown in the following table.

Source	Experiment 1		Experiment 2	
	Germination	*Damping-off*	*Germination*	*Damping-off*
	%	%	%	%
P. obconica	81	2	83	2
Tomato	69	0	75	3
Rape	62	1	82	1
Cucumber	65	3	77	1
Control	93	0	93	0

The aggregate loss varied from 10 to 30 per cent. No doubt the incidence of damping-off would have been higher if the seedlings had been sown more closely for damping-off caused by *Pythium* is usually associated with overcrowding and overwet soil.

Reference

Cook, W. R. Ivimey and Collins, W. B. (1937). *Trans. Brit. Myc. Soc.*, 21, Nos. 1 and 2, 29–33.

4. (a) STEM ROT OF TOMATO CAUSED BY DIDYMELLA LYCOPERSICI

By ENID SHEARD

Aerial Spore Transmission

The work on aerial transmission of spores which was started in 1945 was continued. In all the 1946 tests the petri dishes containing Dox agar were exposed with the agar surface facing upwards for one minute. In the glasshouses plates were exposed both at ground level and 6 ft. above the ground: out of doors all the plates were placed on the ground. After incubating the plates for several days any colonies which resembled *Didymella* were transferred to agar slopes. Tomato stems were inoculated with these cultures and any lesions which resulted were compared with those produced when stems were inoculated with a pure culture of *D. lycopersici* to determine whether the trapped spores were indeed those of *D. lycopersici*.

Plates were exposed on a nursery (A) in the Lea Valley where many plants had been lost from stem rot in 1945 and the results for both years are given in Table IX.

TABLE IX

DIDYMELLA SPORES TRAPPED ON NURSERY A, 1945–46

Date	No of Plates yielding *Didymella*			Remarks
	Glass-houses	Out of doors	Total	
June 15, 1945 ...	5		5	Infected plants growing in houses. No plates exposed outside.
July 6, 1945 ...	2	2	4	Houses were empty and had been without glass since the end of 1944.
Nov. 6, 1945 ...	2	2	4	
Dec. 6, 1945 ...	2	2	4	Houses had been steamed and sprayed with formaldehyde but infected plants were present in untreated house in the same block.
Jan. 4, 1946 ...	0	5	5	Houses empty.
Jan. 24, 1946 ...		3	3	No plates exposed under glass.
Feb. 8, 1946 ...	0	1	1	Haulms with viable spores found in neighbourhood.
Mar. 5, 1946 ...	0	1	1	Houses being planted up.
Mar. 21, 1946...	0	2	2	
Apr. 4, 1946 ...	1	1	2	First infected plant found in house next to and continuous with one in which recorded plate was exposed.
Apr. 18, 1946 ...	0	1	1	More infected plants found.

It will be seen that viable spores were present outside the houses during the winter months when the houses were empty and the discovery of infected haulms bearing pycnidia which contained viable spores suggests that spores trapped out of doors when the houses were empty came from infected tomato haulms which had not been burnt at the end of the season.

It is interesting to note that the first spore was trapped under glass this season on the day on which the first infected plant was found. The plant was close to the place in which the plate yielding *Didymella* was exposed.

On April 18th a number of infected plants were found in another house and the experiment was discontinued.

Plates were exposed after the houses had been planted on another nursery (B) where a serious loss of plants from stem rot had occurred in 1945. (See Table X.)

TABLE X

DIDYMELLA SPORES TRAPPED ON NURSERY B, 1946

Date	Plates yielding *Didymella*	
	In Glasshouses	Out of Doors
Mar. 13	0	0
Apr. 12	0	1
May 9	0	1

At the beginning of May one infected plant was found on the nursery, but no more plants were lost from *Didymella* stem rot throughout the season. An adjacent nursery, however, lost a number of plants under glass from *Didymella* during the year.

The results of the tests carried out on the two nurseries show that it is possible for an attack of stem rot under glass to be started by air-borne spores from some source outside the glasshouse.

Toxicity of Fungicides to Didymella Spores

The results of tests made with a number of fungicides on *Didymella* spores are given in the Annual Report for 1945. Further tests have been carried out this year with some of these compounds and with a number of others.

Spores were (a) left in the solution, (b) treated with the solutions for one hour, centrifuged and drained, and (c) treated for one hour, centrifuged and washed in distilled water. The treated spores were germinated in dilute tomato juice. The details of the method used are described in the Annual Report for 1945, p. 34. Table XI gives the highest concentration at which germination of some of the spores took place and the lowest concentration at which there was no germination. The results with ethyl mercuric phosphate are quoted from last year's Report for comparison.

TABLE XI

Effect of Chemical Compounds on Spore Germination

Solution	Lowest toxic and highest non-toxic concentrations					
	Spores in Solution		Spores treated for 1 hr.			
			Centrifuged		Centrifuged and Washed	
	Germination	No Germination	Germination	No Germination	Germination	No Germination
8 hydroxyquinoline sulphate	1 : 500	1 : 200	1 : 500	1 : 200	1 : 500	1 : 200
n-Propyl Mercuric Chloride	—	1 : 20,000	—	1 : 20,000	—	1 : 20,000
Ethyl Mercuric Phosphate	1 : 1,000,000	1 : 700,000	1 : 1,000,000	1 : 700,000	1 : 500,000	1 : 200,000
Tar Acid Sterilising Fluid	1 : 5,000	1 : 2,000	1 : 50	—	1 : 50	—
Shirlan AG	1 : 3,000	1 : 2,000	1 : 100	1 : 50	1 : 500	1 : 250

8 hydroxyquinoline sulphate, Shirlan AG and a proprietary tar acid sterilising fluid are seen to be much less toxic to *Didymella* spores than ethyl mercuric phosphate and n-propyl mercuric chloride.

To determine the concentration of n-propyl mercuric chloride required to kill spores in the presence of soil, 100 ml. of the solutions to be tested were shaken with 100 gm. of air-dry maiden loam for one hour and spores treated with the filtrate. The results are shown in Table XII.

TABLE XII

Effect of Mercuric Compounds after Contact with Soil on Spore Germination

Solution	Lowest toxic and highest non-toxic concentrations					
	Spores in Solution		Spores treated for 1 hr.			
			Centrifuged		Centrifuged and Washed	
	Germination	No Germination	Germination	No Germination	Germination	No Germination
n-Propyl Mercuric Chloride	—	1 : 20,000	1 : 15,000	1 : 10,000	1 : 10,000	—
Ethyl Mercuric Phosphate	1 : 25,000	1 : 20,000	1 : 25,000	1 : 20,000	1 : 25,000	1 : 20,000

The results show that n-propyl mercuric chloride in the presence of soil is less toxic to *Didymella* spores than ethyl mercuric phosphate.

Dusts.—The toxicity of Shirlan dust, calomel dust and flowers of sulphur to *Didymella* spores was tested by placing a spore suspension in dilute tomato juice on slides and adding the dusts. Spores germinated readily in the presence of calomel dust and flowers of sulphur but there was no germination in the presence of Shirlan dust. Shirlan dust, however, does not give complete control of *Didymella* on tomato stems.

Length of Time the Surfaces of Soils treated with Fungicides remain Toxic to Didymella Spores

Experiments to determine the length of time the surface of soil treated with formaldehyde and tar acid sterilising fluid remained toxic to *Didymella* spores were described in the Annual Report for 1945. Similar experiments were carried out this year, using ethyl mercuric phosphate. Wooden boxes 14 ins. by 8 ins. by 6 ins. were filled with soil from a tomato border, the surface was tightly pressed down and the solutions applied with a fine rose to wet the soil to a depth of 1 in. In some boxes the soil had been steamed and in others it was unsteamed. The boxes were covered with perforated cellophane and the soil kept damp with tap water throughout the experiment. Glass cylinders were pressed into the soil and a spore suspension in water pipetted onto the surface of the soil within the cylinders. After 24 hours portions of the surface layer of soil within the cylinders were transferred to agar slopes which were examined later for *Didymella*. Spores were put on to fresh areas of the soil surface at weekly intervals. The results are shown in Table XIII.

TABLE XIII

Toxicity of Soil Surface to Didymella Spores after Treating with Ethyl Mercuric Phosphate

Time after Treatment at which Spores were Applied	No. of areas Treated	No. of Areas from which *Didymella* was Isolated		
		Ethyl Mercuric Phosphate		Water
		1 : 5,000	1 : 10,000	
Immediately	6	0	0	6
3 days	6	0	0	6
7 ,,	6	0	0	5
14 ,,	6	0	0	5
21 ,,	6	0	0	6
28 ,,	6	0	1	6
35 ,,	6	0	2	6
42 ,,	6	1	2	6
49 ,,	6	0	6	5
56 ,,	6	2	6	6
63 ,,	6	3	6	6
70 ,,	6	6	6	6

The surface of soil soaked with ethyl mercuric phosphate at a concentration of 1 : 5,000 will remain toxic to free *Didymella* spores for seven weeks and at 1 : 10,000 for three weeks. This compares favourably with formaldehyde (1 : 49) applied at the same rate, which was found to lose its power to kill free spores on the surface of the soil one week after treatment.

In experiments described below, ethyl mercuric phosphate at a concentration of 1 : 10,000 was found to damage young tomato plants, consequently further experiments were carried out at a concentration of 1 : 15,000 which was found to be safe to use after planting up. Boxes of damp steam sterilised loam were watered with ethyl mercuric phosphate at this concentration at the rate of 1 quart per square yard and 1 gallon per square yard. *Didymella* spores were put on to the surface of the soil, 1, 8 and 15 days after treatment and the boxes were kept damp with water during that time. Isolations made from the treated soil showed that most of the spores put on the soil one day after treating with ethyl mercuric phosphate 1 : 15,000 at the rate of 1 quart per square yard were killed whereas at the rate of 1 gallon per square yard all the spores were killed. In 8 days the surface of soil treated at the rate of 1 quart per square yard had ceased to be toxic to spores and in 15 days soil treated at the rate of 1 gallon per square yard had ceased to be toxic to spores.

Because of the inconclusive results obtained in 1945 with a tar acid sterilising fluid experiments were carried out in which several applications of the fluid were given to the soil. The solution was used at a concentration of one part in 1,500 parts water, the highest concentration which could be used on soil in which young tomato plants were growing without damaging them. 140 ml. of solution were watered on to the surface of steamed soil in 6-in. pots (approximately 1½ gallons per square yard) at two-day intervals, and a spore suspension was pipetted on to the surface of the soil 1, 5

and 10 days after one, two and three applications. Isolations were made as in the previous experiments. The results are summarised in Table XIV.

TABLE XIV

No. of Treatments	No. of Days between Treatment and applying Spores	No. of Pots	No. of Pots yielding *Didymella*	
			Tar Acid Fluid 1 : 15,000	Water
1	1	4	4	4
	5	4	4	4
	10	4	4	4
2	1	4	4	4
	5	4	3	4
	10	4	4	4
3	1	4	3	4
	5	4	4	4
	10	4	2	3

The results show that while one treatment is ineffective three treatments have some injurious effect on the fungus. Tar acids, however, at concentrations which can be used on the soil after planting were much less effective against *Didymella* spores than ethyl mercuric phosphate used under the same conditions.

The Effect of Ethyl Mercuric Phosphate on Tomato Plants

Plants in Three-inch Pots

Tomato plants showing four rough leaves were watered with 50 ml. of different concentrations of ethyl mercuric phosphate. After six days, the control plants watered with tap water were healthy and the cotyledons remained green. At a concentration of 1 : 2,000 two plants collapsed at soil level and the remaining four showed scorched roots and hypocotyls but the stems did not collapse. Similar results were obtained with concentrations of 1 : 5,000 and 1 : 10,000. At a concentration of 1 : 20,000 none of the plants collapsed but the lateral roots turned brown and the cotyledons turned yellow. These plants recovered after receiving this check and it is concluded that a 1 : 20,000 solution can be used on plants of this size.

In subsequent experiments, plants in 3-in. pots and showing four rough leaves were watered with ethyl mercuric phosphate at concentrations of 1 : 10,000, 1 : 15,000 and 1 : 20,000 and at the rates of 50, 25 and 10 ml. per pot. None of the treated plants collapsed but when compared with the control plants which received water only, they appeared stunted. Stunting of the treated plants occurred in the following order, the most severe stunting being placed first, 1 : 10,000—50 ml., 1 : 15,000—50 ml., 1 : 20,000—50 ml., 1 : 10,000—25 ml., 1 : 15,000—25 ml., 1 : 20,000—25 ml., 1 : 10,000—10 ml., 1 : 15,000—10 ml., 1 : 20,000—10 ml., thus the extent of the damage to the plants appeared to depend on the volume of solution applied more than on the concentration of the solution used.

Aerial Parts of Plants

Tomato plants in 6-in. pots with the first truss set were sprayed overhead with a 1 : 15,000 solution of ethyl mercuric phosphate. After a week treated plants appeared to be slightly hardened when compared with control plants which had been sprayed with water.

The lower leaves of tomato plants in 6-in. pots were removed in order to provide the best conditions for infection and the plants were sprayed with a 1 : 15,000 solution of ethyl mercuric phosphate. After an hour the wounds made by removing the leaves were lightly sprayed with a suspension of *Didymella* spores. The results of two experiments are summarised in Table XV.

TABLE XV

Series	No. of Plants Sprayed	No. of Leaf Scars	No. of Infections			
			Ethyl Mercuric Phosphate		Water	
			Plants	Lesions	Plants	Lesions
1	12	48	0	0	1	1
2	6	24	0	0	5	12

The low number of lesions in the first experiment was due to the hot, dry weather at the time of the experiment which was unfavourable to *Didymella* infection.

At lower concentrations less favourable results were obtained as follows:—

TABLE XVI

Spray	No. of Scars	No. of Lesions
Water	24	22
Ethyl Mercuric Phosphate 1 : 500,000 ...	24	20
„ „ „ 1 : 100,000 ...	24	12

Different concentrations of ethyl mercuric phosphate were compared with Shirlan AG 1 : 50, which had been recommended as the spray which hitherto had given the best control against *Didymella*, with the following results.

TABLE XVII

Spray	No. of Leaf Scars	No. of Infections	
		Series 1	Series 2
Water	24	17	19
Ethyl Mercuric Phosphate 1 : 100,000 ...	24	14	19
„ „ „ 1 : 75,000 ...	24	10	19
„ „ „ 1 : 50,000 ...	24	9	16
„ „ „ 1 : 25,000 ...	24	5	7
Shirlan AG ... ... 1 : 50 ...	24	14	21

Under the conditions of the experiment, ethyl mercuric phosphate at a concentration of 1 : 25,000 is more effective in preventing infection of tomato stems by *Didymella* than Shirlan AG 1 : 50.

When 1 : 15,000 ethyl mercuric phosphate was painted on to lesions on tomato stems the spores within the pycnidia were not killed and therefore it is of no use in destroying existing lesions.

The Effect of Ethyl Mercuric Phosphate on the Flavour of Tomato Fruit

The application of solutions of certain organic mercurial compounds to the soil in which tomato plants are grown has been found to impart an unpleasant flavour or taint to the fruit. No difference in flavour could be determined between ripe fruit held for 24 hours over 1 : 5,000 ethyl mercuric phosphate in a closed vessel and fruit from the same plant held over water, nor was the fruit tainted five days after the plants on which it was growing were watered with a solution of the same concentration.

Tomato plants growing in 3-in. pots were watered with a 1 : 10,000 solution of ethyl mercuric phosphate, enough solution being applied to saturate the soil. Later the plants were potted into 6-in. pots and the first trusses of fruit ripened. No tainting of the fruit, compared with fruit from similar plants given water only, was detected from the plants treated with ethyl mercuric phosphate, nor could any tainting of fruit be detected from plants grown on a commercial nursery on which a large-scale experiment had been carried out and the soil had been treated with ethyl mercuric phosphate 1 : 15,000 before planting up. It is concluded that 1 : 10,000 ethyl mercuric phosphate can be applied at any stage from 3-in. pots to fruiting plants without tainting the fruit.

Penetration of Soil by Didymella

In previous experiments attempts to isolate *Didymella* from naturally infected soils had failed when isolations were made more than 2 ins. below the surface of the soil. The fungus, therefore, was cultured in tubes of soil to determine whether it could penetrate to any depth in the soil. Wide tubes were filled with moist loam which was firmed down. Half the number of tubes was sterilised in the autoclave and the rest left unsterilised. Portions of a sand-oatmeal culture of *Didymella* were placed on the soil surface in each tube and the tubes were incubated at 20° C. for six weeks. Portions

of soil were removed at ½-in. intervals down the tubes and transferred to Dox agar slopes. See Table XVIII.

TABLE XVIII

DEPTH OF SOIL THROUGH WHICH DIDYMELLA CAN PENETRATE

Depth in Inches	No. of Isolations	No. of Isolations yielding *Didymella*	
		Sterilised	Unsterilised
½	12	9	2
1	12	4	0
1½	12	1	0
2	12	1	0
2½	12	2	0
3	12	1	0

The results show that *Didymella* grows most readily in the top ½-in. of the soil and that penetration in steam sterilised soil is deeper than in unsteamed soil.

The Effect of Sugars on the Growth of Didymella

Results obtained by a colleague suggested that the addition of glucose to soil infected with *Phytophthora cryptogea* reduced the number of tomato seedlings which damped-off in that soil and the same method was tried against *Didymella*. Soil from a tomato border was steamed and mixed with a sand-oatmeal culture of *D. lycopersici* and the mixture placed in sterilised seed boxes, each box holding 3,500 gm. soil and 200 gm. culture. 300 ml. of 4 per cent. aqueous glucose solution were watered onto the surface of the soil in each box immediately after mixing and at weekly intervals, four applications being given. A similar series of boxes was watered with distilled water and all the boxes were covered with damp hessian. Three weeks after the last application and six weeks after the soil had been inoculated tomato plants were potted into 6-in. pots partly filled with sterilised loam and a 3-in. pot full of the infected soil was added to the top of each pot.

Plants began to wilt three weeks after potting into inoculated soil and after six weeks the following results were obtained:—

TABLE XIX

	Infected	Not Infected	Total
4% Glucose Solution ...	15	5	20
Water	2	18	20

The results show that the amount of glucose added to the infected soil (approximately 1·4 per cent. by weight) greatly increased the number of plants infected.

Because the addition of glucose to an infected soil increased the number of plants becoming infected it seemed likely that fungus grew more rapidly using the glucose as a source of carbon. It is known that *Didymella* infection is more severe in some soils than in others and it seems possible that the sources of carbon in the different soils may influence the growth of *Didymella* in them. Pure culture experiments were carried out to determine if different carbon sources influenced the rate of growth of the fungus. The fungus was grown at 20° C. on Dox agar and on modifications of the medium in which the 3 per cent sucrose was substituted by 3 per cent. glucose, maltose, lactose, lævulose, galactose, manitol and potato starch. There was no appreciable difference in the daily increase in diameter of the colonies of any of the media. Using 3 per cent. manitol, however, a very sparse growth was obtained, compared with the compact, dense growth on the other media. It is concluded that *Didymella* can utilise a number of sugars and starch equally well, while manitol (a hexahydric alcohol) is a less suitable source of carbon.

Experiments are in progress in which a number of natural and synthetic sources of carbon have been added to infected soil in an attempt to determine if they affect the incidence of the disease.

4. (b) DIDYMELLA STEM-ROT INVESTIGATIONS

By W. H. READ

Possibly the most significant feature of the investigations concerning the control of *Didymella lycopersici* was the failure of the first series of trials on the Experimental Station nursery due to the non-appearance of the fungus. These trials were designed to obtain further information on the value of treating the surface of the soil with formaldehyde and tar acid sterilising agents prior to planting out tomatoes.

At the conclusion of the 1945 experiments, with pre-planting treatments (Annual Report 1945, page 42) 43 per cent. of the plants in the house had been destroyed by *Didymella*. The remaining plants were removed and the border soil in half the house was sterilised by steaming. The soil in the other half of the house was untreated except for the normal digging.

Owing to limitations of space and the necessity for economy in fuel it was necessary to employ the house for the propagation of the cucumber crop and in consequence the usual staging was erected in part of the house and cucumbers grown on it. Following the removal of the cucumbers a fertiliser mixture consisting of equal parts of dried blood, superphosphate and sulphate of potash was raked into the borders at the rate of ½ lb. per square yard and the borders were watered. Holes were dibbed in the usual manner and the "sterilised" and "unsterilised" halves of the house each divided into 10 plots. In each group of 10 plots three were watered with a 1 in 50 solution of commercial 38 per cent. formaldehyde at the rate of 1 gallon per square yard, three watered with a 1 in 100 solution of a proprietary tar acid soil sterilising fluid and four plots untreated, the treatments being randomised in both cases. A fortnight later all the plots were planted up with tomatoes in the normal way. The plants were given standard cultural conditions there after. No plants in either the sterilised or unsterilised portions of the house were attacked at the base of the stem by *Didymella* and when, 18 weeks after planting, it was obvious that the experiment had failed to yield the required information, the plants were used for experiments with fungicides for the prevention of *Didymella* infections of stem wounds caused by trimming off shoots and leaves.

Although a number of reasons for the absence of *Didymella* attack could be suggested they would, at this stage, be speculations unsupported by any experimental evidence.

A number of field trials on lines similar to the above were made on commercial nurseries where losses due to *Didymella* were serious in 1945. Glasshouses on these nurseries were treated by applying either a 1 in 50 solution of commercial 3 per cent. formaldehyde or a 1 in 100 dilution of a proprietary tar acid sterilising fluid (41 per cent. phenol content) to the soil at the rate of 1 gallon per square yard. The applications were made about, but not less than, 14 days before planting.

The results of these trials were disappointing and failed to confirm those obtained in 1945 (Annual Report 1945, page 42), since there was no evidence that either treatment reduced the losses due to attack by *Didymella* at the base of the stems of the tomatoes.

Experiments with Ethyl Mercuric Phosphate

Laboratory experiments conducted by Mrs. Sheard showed that organic mercury compounds were toxic to spores of *Didymella* at very low concentrations and that ethyl mercuric phosphate was the most potent of the compounds tested. The toxicity of ethyl mercuric phosphate was not so greatly reduced in the presence of soil as to preclude its practical use and furthermore it is sufficiently soluble in water to avoid technical difficulties in its application. Ethyl mercuric phosphate also possesses the advantage over formaldehyde and tar acid sterilising fluids in that it can be applied to the soil at an effective concentration immediately before planting without injury to tomatoes and where this is done the soil remains toxic to the fungus for several weeks after planting.

On the other hand, ethyl mercuric phosphate is highly poisonous both when taken internally or inhaled as a vapour and the solid material or strong solutions of it have a vesicant action if allowed to remain in contact with the skin. If care is taken, however, there should be no greater danger attached to its use than to other poisons used in the industry.

Sufficient ethyl mercuric phosphate was obtained for some large-scale trials on commercial nurseries, and the results appeared very promising, both where ethyl mercuric phosphate was applied to the soil before planting and where the planted border soil was treated with the solution to check the spread of *Didymella*. The strength of the solution used in these trials was 1 in 16,000 and it was applied to the soil at dosages of 0·4 to 1 gallon per square yard with a spraying machine.

An experiment was conducted in a glasshouse at the Experimental Station to determine the effect of allowing different periods ot elapse between the time of inoculation of a sterilised soil with *Didymella* and the time of the application of ethyl mercuric phosphate, on the efficiency of the

treatment. Unfortunately, considerable delay occurred in obtaining a steam boiler for the sterilisation of the border soil which made it impossible to use the first batches of plants propagated for the experiment and a comparison with other treatments could not be included.

Experimental

Ten plots, each 10 ft. by 4 ft., were arranged in a glasshouse. The soil of eight plots was sterilised by steaming while the remaining two were dug but otherwise untreated. Three days after the completion of steaming the soil in all the plots was inoculated with *Didymella* by watering on a suspension of spores obtained from diseased tomato stems. Uniformity of inoculation was obtained by employing dilutions of a single suspension and applying 2 gallons of the diluted suspension to each plot with a watering-can fitted with a fine rose. The holes in which the tomatoes were to be planted were then dibbed in all the plots.

Pairs of sterilised plots, one of which was watered with a 1 in 16,000 solution of ethyl mercuric phosphate at the rate of 1 gallon per square yard, were planted with tomatoes at periods of three days, and two, four and 10 weeks after the inoculation of the soil. The treatments with ethyl mercuric phosphate were made two days before planting.

One unsterilised plot was planted with tomatoes three days after inoculation and the second 10 weeks after inoculation. Three plots were not treated with ethyl mercuric phosphate and the object of including them in this trial was to determine the effect of soil sterilisation on the survival of the fungus in a soil. Normal cultural conditions were maintained. A rose was fitted to the hose when watering to avoid washing soil from untreated plots to adjacent treated plots. Diseased plants were removed from the plots when wilting was evident and their roots were examined to verify that they were attacked by *Didymella*. The experiments were continued for a period of 12 weeks from the time the plots were planted except for the plots planted 10 weeks after inoculation of the soil where circumstances necessitated the conclusion of the test nine weeks after planting.

Results

The percentages of plants attacked by *Didymella* in the various plots at periods of three, six, nine and 12 weeks after planting are given in Table XX.

TABLE XX

	Weeks after Planting	Percentage of Plants attacked by *Didymella*	
		Plot treated with Ethyl Mercuric Phosphate	Untreated Check Plot
Plots planted three days after inoculation	3	0	8
	6	5	83
	9	11	100
	12	22	100
Plots planted two weeks after inoculation	3	0	0
	6	5	40
	9	16	50
	12	22	100
Plots planted four weeks after inoculation	3	11	22
	6	11	44
	9	11	89
	12	11	100
Plots planted 10 weeks after inoculation	3	0	5
	6	0	11
	9	0	44
Unsterilised plot planted three days after inoculation ...	3		5
	6		16
	9		22
	12		44
Unsterilised plot planted 10 weeks after inoculation ...	3		0
	6		0
	9		0

It is seen that the treatment with ethyl mercuric phosphate was as effective in reducing losses of plants by *Didymella* when applied 10 weeks after the soil had been inoculated as when applied three days after inoculation.

Although complete control was not obtained the treatment gave very considerable reduction in the number of plants attacked.

No injurious effect on the growth of the tomato plants was observed throughout these tests.

On commercial nurseries spores of *Didymella* may be carried in air currents and continually gain access to the soil, consequently it is probable that the greatest degree of control will be obtained where the soil is treated a few days before planting. Further experiments are necessary to determine the effect of applying ethyl mercuric phosphate after planting, on the spread of *Didymella*.

The fungus added to the soil sterilised by steaming continued to live and caused the loss of a high proportion of the plants 12 weeks after it was inoculated.

Not only was the loss of plants in the unsterilised soil less than in the sterilised soil when plants were planted out three days after the soils had received equal amounts of inoculum, but the fungus either failed to persist or was unable to attack plants grown in the soil 10 weeks after it was inoculated.

PLANT SPRAYING EXPERIMENTS

(1) Organic Mercury Compounds

The loss of tomato plants in full bearing due to infection of their stems well above soil level, by *Didymella* was exceptionally severe in glasshouses in 1946. It is usual for these infections to occur where the stems have been wounded by the removal of leaves and shoots or where they have been rubbed by the supporting strings. In view of the serious nature of these losses a number of fungicides were tried as preventives of the infection of wounds on tomato stems. The purpose of the trials was to find a treatment which would reduce these losses sufficiently to justify its commercial application and not for the accurate comparison of the efficiencies of the various compounds. The conditions appertaining to the control of wound infections are not readily stimulated in *in-vitro* tests and the results of a laboratory method employing detached portions of tomato stem did not yield results comparable with those obtained on growing plants.

Experimental

Two series of trials with the object of determining (a) the true protective value of the fungicide, and (b) if the fungicide would prevent the development of *Didymella* on wounds inoculated with spores of the fungus 24 hours before the application of the fungicide. The methods employed were as follows:—

Experiment 1(*a*)

The stems of the plants were wounded in five places by the removal of shoots or leaves. Four hours afterwards the stems of the plants were sprayed with the fungicidal mixtures and 24 hours later the wounds were lightly sprayed with a suspension of spores of *Didymella*.

Experiment 1(*b*)

The stems of the plant were wounded as in (*a*). Four hours later the wounds were lightly sprayed with a suspension of *Didymella* spores and after a further 24 hours the stems were sprayed with the fungicides.

The spore suspensions were applied to each wound as uniformly as possible with a scent spray. One suspension was used for all the plants in series (a) and another for all the plants in series (b). Duplication of the treatments was obtained by conducting each one on both sides of the house and the treatments in (a) and (b), together with the unsprayed checks, were randomised on each side. The plants employed in the test were planted in the border of a cucumber house and were 26 weeks old when the experiment commenced.

The number of lesions caused by the infection of wounds by *Didymella*, which developed within five weeks from the commencement of the experiment, were recorded.

Organic mercury compounds have been shown toxic to *Didymella* at very low concentrations and were therefore employed in the first series of trials. An account of tests with ethyl mercuric phosphate conducted by Mrs. Sheard appear elsewhere in this report. Ethyl mercuric phosphate was not included in these trials because its volatility would almost certainly prohibit its use as a foliage spray in glasshouses. The "Venturicide" and "Mercurated D.D.T." preparations were included since they are existing proprietary products containing phenyl mercury chloride in a form suitable for practicable application. The use of phenyl mercury chloride for the control of apple scab (*Venturia inæqualis*) has been investigated by H. Shaw[1]. "Liquid Venturicide" is a preparation

containing 2 per cent. phenyl mercury chloride in a Kaolin suspension, and "Mercurated D.D.T." a dispersible powder containing 1·5 per cent. phenyl mercury chloride and 10 per cent. D.D.T.

The organic mercurials, with the exception of the n-amyl mercury chloride-Kaolin suspension and the proprietary products mentioned above, were made suitable for spray application by triturating one part of the compound with two parts of sulphite lye powder and a little water. The n-amyl mercury chloride-Kaolin suspension was prepared by triturating one part of the mercurial with 10 parts of Kaolin and sufficient water to yield a thin paste. 0·075 per cent. "Liquid Agral" was incorporated in all the spray fluids other than those containing "Venturicide" and "Mercurated D.D.T."

Results

The number of lesions which developed on the plants in the various plots are tabulated. Table XXI gives the results obtained in Experiment 1(a) where the wounds were sprayed with the test substances before being inoculated and Table XXI the results obtained in Experiment 1(b) where the wounds were inoculated with *Didymella* before being sprayed with the mercury compounds.

None of the spray treatments gave results of practical value in preventing loss of plants through *Didymella* infection of stem wounds.

Although it would appear from the tabulated results that the mercury compounds were without effect in preventing wound infections, it was apparent, when the numbers of lesions on each plot were considered in relation to the position of the plot in the house, that the position of the plot was a most important factor influencing the degree of wound infection. The number of lesions per plot tended to be at a maximum at the middle of each border and to decrease towards either end in both experiments. The number of lesions on the check plots, however, exceeded those of adjacent treated plots indicating that the treatments reduced the number of wounds becoming infected. The magnitude of the positional effect shown in these trials, conducted in a glasshouse 100 ft. long by 13 ft. wide, showed the extent to which infections of stem wounds on tomatoes by *Didymella* is affected by slight variations in external conditions.

All the mercurials tested caused injury to tomato foliage at a concentration of 0·01 per cent. No injury was observed when the compounds were used at a concentration of 0·0025 per cent. Some evidence has been obtained from other experiments that fruit setting of tomatoes may be adversely affected by spraying with organic mercury compounds at concentrations which cause no apparent foliage injury.

TABLE XXI

Experiment 1A

Spray Material	Concentration of Mercury Compound in Spray	Percentage of Wounds infected by *Didymella*	
		East Border	West Border
n-Cetyl Mercury Chloride	·01 %	67	53
" " "	·0025 %	87	67
n-Amyl " "	·01 %	27	33
" " "	·0025 %	40	80
n-Butyl " "	·01 %	40	53
" " "	·0025 %	20	93
n-Propyl " "	·01 %	53	53
" " "	·0025 %	33	33
Phenyl " "	·01 %	67	27
" " "	·0025 %	60	53
Phenyl " Acetate	·01 %	40	13
" " "	·0025 %	87	13
"Venturicide" (2 % Phenyl Mercury Chloride)	·01 %	67	40
" " "	·0025 %	40	50
"Mercurated D.D.T." (1·5 % Phenyl Mercury Chloride)	·01 %	27	67
n-Amyl Mercury Chloride-Kaolin Suspension	·01 %	20	73
Unsprayed Check 1		67	67
" " 2		93	40
" " 3		27	13
" " 4		53	13

EXPERIMENT 1B

Spray Material	Concentration of Mercury Compound in Spray	Percentage of Wounds infected by *Didymella*	
		East Border	West Border
n-Cetyl Mercury Chloride	·01 %	67	27
„ „ „	·0025 %	13	7
n-Amyl „ „	·01 %	53	13
„ „ „	·0025 %	13	33
n-Butyl „ „	·01 %	53	73
„ „ „	·0025 %	67	13
n-Propyl „ „	·01 %	20	53
„ „ „	·0025%	73	67
Phenyl „ „	·01%	47	33
„ „ „	·0025%	67	27
Phenyl „ Acetate	·01%	20	
„ „ „	·0025%	67	40
""Venturicide" (2 % Phenyl Mercury Chloride)	·01%	67	53
„ „ „ „	·0025%	47	80
"Mercurated D.D.T." (1·5 % Phenyl Mercury Chloride)	·01%	47	13
n-Amyl Mercury Chloride-Kaolin Suspension	·01%	33	40
Unsprayed Check 1		80	100
„ „ 2		93	93
„ „ 3		27	67
„ „ 4		10	47

(2) Polyethylene polysulphide

High polymers of organic polysulphides were investigated by W. D. Stewart and J. H. Standen[2], who found that aqueious dispersons were suitable as spray materials. They state that polymers of high sulphur content are fungicidal and furthermore that they form elastic films of unusual tenacity when sprayed on plants.

Although sulphur compounds have not proved strongly fungicidal to *Didymella* it was considered that the above products might be of value if they would form a film over the surface of wounds on tomato stems. A quantity of "Omilite latex" containing 40 per cent. of the active polyethylene polysulphides in suspension was obtained and tried as a spray for the prevention of infection of stem wounds on tomatoes by *Didymella*. The first trials were conducted in the same general manner as those with the organic mercurials except that pot plants, about 4 ft. in height, were employed and positional effects were avoided by grouping the plants. In the second experiment the stems were sprayed with the polyethylene polysulphide suspension two or 24 hours after wounding; in other respects experimental details were as in the first test.

RESULTS

The results of these tests are tabulated (Tables XXII and XXIII) and show that although the product was employed at the relatively high concentrations of 1 in 320 and 1 in 160 it failed to give adequate prevention of wound infections under the conditions of the tests.

TABLE XXII

EFFECT OF 1 IN 320 "OMILITE LATEX" (40 PER CENT. POLYETHYLENE POLYSULPHIDES) ON STEM-WOUND ATTACKED BY DIDYMELLA

Treatment	Number of Lesions caused by *Didymella* (Possible 45)	Number of Plants Attacked (Possible 8)
Stems sprayed four hours after wounding. Inoculated 24 hours after spraying	9	4
Unsprayed Check Plants	8	5
Stems inoculated four hours after wounding. Sprayed 24 hours after inoculation	15	7
Unsprayed Check Plants	14	8

TABLE XXIII

Effect of 1 in 160 "Omilite Latex"

	Number of Lesions (Possible 36)	Number of Plants Attacked (Possible 6)
Plants sprayed two hours after wounding. Inoculated 24 hours after wounding	14	6
Unsprayed Check Plants	27	6
Plants sprayed 24 hours after wounding. Inoculated 48 hours after wounding	18	6
Unsprayed Check Plants	21	6

The greater number of lesions and plants attacked in the test with 1 in 320 "Omilite Latex" (Table XXII) where the stems were inoculated four hours after wounding, as compared with those inoculated 24 hours after wounding, does not necessarily signify that wounds are more susceptible to infection when freshly made. The difference in this case was possibly due to a bright sunny period immediately following the inoculation.

Acknowledgments

We wish to thank the following firms for supplying organic mercury compounds: Messrs. F. W. Berk & Co., Ltd.; Messrs. Boots Pure Drug Co., Ltd.; and Messrs. Lunevale Products, Ltd.; also Dr. W. D. Stewart of the Boyce Thompson Institute and Dr. S. L. Hopperstead of the B.F. Goodrich Chemical Company, Ohio, for help in obtaining the polyethylene polysulphide product "Omilite Latex."

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5. (a) THE INFLUENCE OF SOIL CONDITIONS ON SUSCEPTIBILITY TO SYSTEMIC INFECTION OF THE TOMATO WITH VIRUSES OF THE TOBACCO MOSAIC GROUP

By IRESON W. SELMAN

During 1946 work has continued on the study of factors affecting the capacity of the plant to resist systemic invasion by mosaic-inducing viruses when these are introduced at relatively low concentrations. The method of inoculating single leaflets with diluted infective sap is intended to stimulate the condition of infection which may occur under nursery conditions in which the juice of diseased plants may be carried on the hands of workers and accidentally rubbed on to parts of plants. Indications have already been obtained that certain fertiliser treatments may increase the susceptibility of plants to infection.

Young Plants in Six-inch Pots

A brief account of the method of the experiment appeared in the Thirty-first Annual Report. A more comprehensive experiment was carried out in the light of preliminary results already reported. Tomato seedlings, variety "Potentate," were planted in 6-in. pots when at the cotyledon stage on June 14th. The pots had been filled with sterilised loam to which had been added fertilisers as shown in Table XXIV. There were thus six levels of superphosphate and two levels of dried blood in all combinations.

On June 28th, when six leaves had developed, the terminal leaflets of the third leaf from the base was inoculated with juice containing Mild Tobacco Mosaic virus. The juice was prepared by grinding up 1 gm. of infected tomato leaves, filtering through cotton wool and making up the crude filtrate to 200 ml. with distilled water.

The leaflet to be inoculated was supported by a wooden plant label and wiped three times with a pad of cotton wool soaked in infective juice. No abrasive was used and the leaflets were not rinsed after inoculation. Immediately prior to inoculation measurements were made on all plants of stem height, the maximum "diameter" or span of the leaves and the number of expanded leaves. This data is included in Table XXIV.

TABLE XXIV

PLANTS POTTED 14TH JUNE. INOCULATED TOBACCO MOSAIC 28TH JUNE

No.	Gm. Fertiliser per 6-in. Pot			Mean Dimensions, 26th June			No. of Plants remaining Virus-free, 17th July
	Dried Blood	Super-phosphate	Sulphate of Potash	Height (cm.)	Leaf No.	Leaf Span (cm.)	
1	2·5	0	1·25	11·6	6·2	27·5	2 out of 5
2	2·5	1·25	1·25	9·8	5·4	26·3	3 „ 5
3	2·5	2·5	1·25	10·2	5·8	27·8	2 „ 5
4	2·5	5·0	1·25	9·7	5·8	28·7	3 „ 5
5	2·5	10·0	1·25	10·2	6·2	27·3	4 „ 5
6	2·5	20·0	1·25	10·4	5·6	26·9	3 „ 5
						Total	17 „ 29
7	5·0	0	1·25	8·2	5·2	22·9	4 out of 5
8	5·0	1·25	1·25	9·4	5·6	22·7	3 „ 5
9	5·0	2·5	1·25	10·7	6·0	25·5	1 „ 5
10	5·0	5·0	1·25	9·4	5·8	26·5	0 „ 5
11	5·0	10·0	1·25	9·5	6·0	27·3	1 „ 5
12	5·0	20·0	1·25	9·7	5·6	27·5	1 „ 5
						Total	10 „ 30

On July 17th, when 12 leaves had developed and the plants were 14–18 ins. in height, symptom-free plants were tested for virus. The young shoot and the leaflet which had been inoculated were each tested separately for virus by macerating and wiping juice on to tomato seedlings and leaves of *Nicotiana glutinosa* plants. There were five plants in each treatment and 12 fertiliser treatments. The number of plants found to be virus free are shown in Table XXIV.

To obtain an indication of the water content of leaflets similar to those which had been inoculated, one of the distal pair of leaflets adjoining the inoculated terminal leaflet was removed from each plant immediately prior to inoculation. These leaflets were weighed in batches of five, dried in an oven and the water content determined. The fresh weights and percentage water contents calculated on a dry matter basis are given in Table XXV.

TABLE XXV

FRESH WEIGHT AND WATER CONTENT OF LEAFLETS ADJOINING TERMINAL INOCULATED LEAFLET

Treatment No.	Mean Fresh Weight (gm.)	% Water Content (On D.M. basis)
1	0·21	688
2	0·18	674
3	0·21	713
4	0·19	671
5	0·22	683
6	0·20	686
7	0·14	567
8	0·18	676
9	0·15	636
10	0·18	677
11	0·22	736
12	0·23	736

It would appear from the data in Tables XXIV and XXV that there is no simple correlation between susceptibility to mosaic infection and either the water content or fresh weight of the leaflets. This is important, for differences in fresh weight might mean differences in stage of development, and it is well known that leaves of differing ages may differ in their susceptibility to virus infection.

As pure chemicals had not been used as fertilisers, a test was made to measure the nitrate and citric-soluble phosphate of the soil in pots containing similar manurial mixtures. Six-inch pots of maiden loam soil were placed in the glasshouse and well watered after first mixing-in the requisite amounts of powdered fertilisers. Twelve days after setting up the pots, samples were taken and analysed for nitrate and citric-soluble phosphate. The results are shown in Table XXVI.

TABLE XXVI

SOIL ANALYSIS (OVEN DRY BASIS)

Treatment		% NO_3	% P_2O_5 Citric sol.
Blood	Super		
0	0	0·0097	0·006
2·5	0	0·0194	0·006
2·5	1·25	0·0189	0·020
2·5	2·5	0·0300	0·030
2·5	5·0	0·0206	0·050
2·5	10·0	0·0185	0·141
2·5	20·0	0·0179	0·247
5·0	0	0·0251	0·061
5·0	1·25	0·0303	0·016
5·0	2·5	0·0296	0·029
5·0	5·0	0·0346	0·052
5·0	10·0	0·0261	0·097
5·0	20·0	0·0202	0·194

All pots received 1·25 gm. sulphate of potash.

From the data in Table XXIV there is evidence to suggest that at the higher level of nitrogen manuring (5·0 gm. blood per pot) more plants became infected with Tobacco Mosaic Virus than at the lower level (2·5 gm. blood). The amount of superphosphate applied to the soil did not appear to be simply related to incidence of infection.

The application of 5·0 gm. blood and 5·0 gm. of superphosphate to the soil resulted in the highest production of nitrate in the soil after 12 days and it was with this soil treatment that 100 per cent. infection occurred (five plants out of five). From the limited data no general correlation could be established between the incidence of infection and either the nitrate level or the citric soluble phosphate level, and further work, with plants growing in a homogeneous medium and supplied with pure chemicals, is called for in this connection.

Three treatments gave relatively good resistance to infection, viz., treatments 5, 6, and 7 in Table XXIV. In selecting a treatment of commercial value, attention must be paid to the type of plant which can be produced with the particular soil treatment under investigation. Thus for example, plants deficient in phosphate may be highly resistant to mosaic infection as Volk (1931) showed, but clearly this fact may not be very helpful to the grower. Consideration of the growth data in Table XXIV for plants of the three most promising treatments indicates that the use of 2·5 gm. blood and 10·0 gm. superphosphate is most promising. A scale diagram is shown in Fig. 1 for the mean height and leaf span values obtained from plants of this group at the data of inoculation. Even from this simple diagram it will be clear to the grower that the plants must have been of a desirable type.

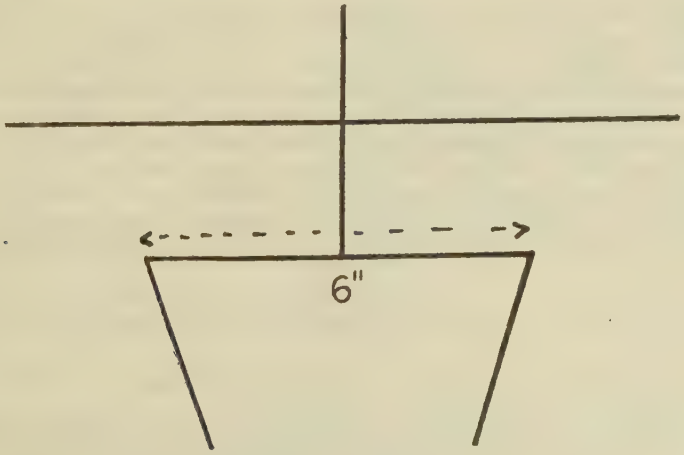

FIG. 1.—*Scale diagram of plant at the six-leaf stage, grown with 2·5 gm. Blood and 10 gm. Super per 6-inch pot.*

From this experiment it was concluded that excessive nitrogen manuring might lead to increased susceptibility to infection as was found by Brierley and Stuart for Yellow Dwarf virus in onions. The fact that the ratio and amounts of blood and superphosphate used seem to be related to the amount of infection may simply be evidence that the phosphate plays some part in controlling the rate of nitrification in the soil, since the soluble phosphate, as determined by analysis, was not related to the incidence of infection.

Work with Fruiting Plants in the Ground

Experiments similar to that reported above have been conducted on fruiting plants growing in the borders of a cucumber house. A full report of this work will appear elsewhere, but it may be stated here that one important result was obtained. Excessive watering was found to decrease significantly the resistance of tomato plants to systemic invasion with Yellow Mosaic virus. This result links on to the observation made in 1927 by Bewley and Corbett, that mosaic infection was very severe on nurseries where the water table was high or in houses where waterlogging occurred. *Breaking up the impervious subsoil*, followed by steaming, resulted in an improvement in the health of the crop. Hitherto it would have been supposed that steaming was probably the major factor in the disappearance of disease, but present investigations suggest that soil conditions affecting the health of the root system are of great importance in this connection.

The results of two successive experiments are summarised below:—

No. of Plants remaining Virus-free in the Leaves following inoculation with Yellow Mosaic	
Wet Border	Dry Border
10 out of 106	26 out of 111

Plants on the dry borders were only watered when this became essential to prevent wilting, whereas plants on the wet borders received a thorough watering over the whole border every three or four days. The duration of the experiments, following inoculation of single leaflets when plants were at the 13–14 leaf stage, was 10 weeks in one experiment and seven weeks in the second.

That soil conditions were unfavourable on the wet border was shown by the fact that virus-free control plants receiving similar treatment showed more yellowing of the lower leaves and a greater proportion of blotchy fruits than did similar plants on the dry soil.

Discussion

The information available so far is consistent with the view that unfavourable soil conditions tend to increase the susceptibility of tomato plants to systemic invasion by mosaic-inducing viruses. Of the factors which tend to increase susceptibility are:—

(1) Excessive applications of sulphate of potash.
(2) Excessive applications of dried blood.
(3) The use of slaked lime in certain soil mixtures.
(4) Over-watering.

All of these factors tend to affect root development adversely. It may be suggested that potash and nitrogen should not be used as "hardening" or "softening" agents in correcting unfavourable types of plant growth. Application of these elements to the soil should be based only upon the nutritional requirements of the crop and high concentrations of these elements in the form of soluble salts in the soil solution should be avoided as far as possible. Where plant growth is too "soft" or too "hard," or truss development is faulty, then control should be effected by the judicious control of water and temperature rather than by the unrestricted use of fertilisers. Much greater use might be made of shading in conserving water supply than is usually done. Control of watering, together with the use of balanced mixtures of dried blood and superphosphate, should do much to increase the resistance of tomato plants to Tobacco Mosaic virus infection under nursery conditions.

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5. (b) ONE METHOD IN WHICH GOOD CULTURE MAY TEND TO ELIMINATE MOSAIC-INDUCING VIRUSES FROM THE TOMATO CROP

By IRESON W. SELMAN

An account has been given in the present report of the way in which certain soil conditions may influence the resistance of the plant to infection with viruses of the Tobacco Mosaic type. Although the nature of such resistance following leaf inoculation is unknown, it is clear that it may be relatively effective under certain conditions. The thickness of the walls of the leaf hairs may perhaps tend to prevent mutilation leading to virus entry, or the virus may, under special circumstances be prevented from multiplying at the site of entry, or again there may be some failure of the virus to move out of the infected area. Whilst these possibilities remain to be elucidated, it may be pointed out that yet another condition has been shown to occur in well-grown, fruiting plants. The virus may multiply at the site of entry and be released into the translocatory system and yet fail to pass to the stem primordia, thereby delaying complete systemic invasion, with its adverse growth effects. An account of the experimental details have been published in the Journal of Pomology, Vol. 22.

It is well known that when all the leaves of a tomato plant are wiped with plant sap containing active Tobacco Mosaic virus, disease symptoms appear in all cases in the young leaves in about seven days in the summer and three weeks in the winter. When, however, infective juice, diluted only 200 times with water, is wiped on to single leaflets of a rapidly-growing plant bearing fruit, localisation of virus has been found to occur in the fruits in some plants.

Now the method of inoculation outlined above is not dissimilar to that which must occur under nursery conditions when for example, the fingers of a nursery worker, sticky with juice from a diseased plant, rubs a leaf or stem of a clean plant. Under such conditions may result the phenomenon, often to be seen on nurseries, of brown "streak," pits or depressions on the green

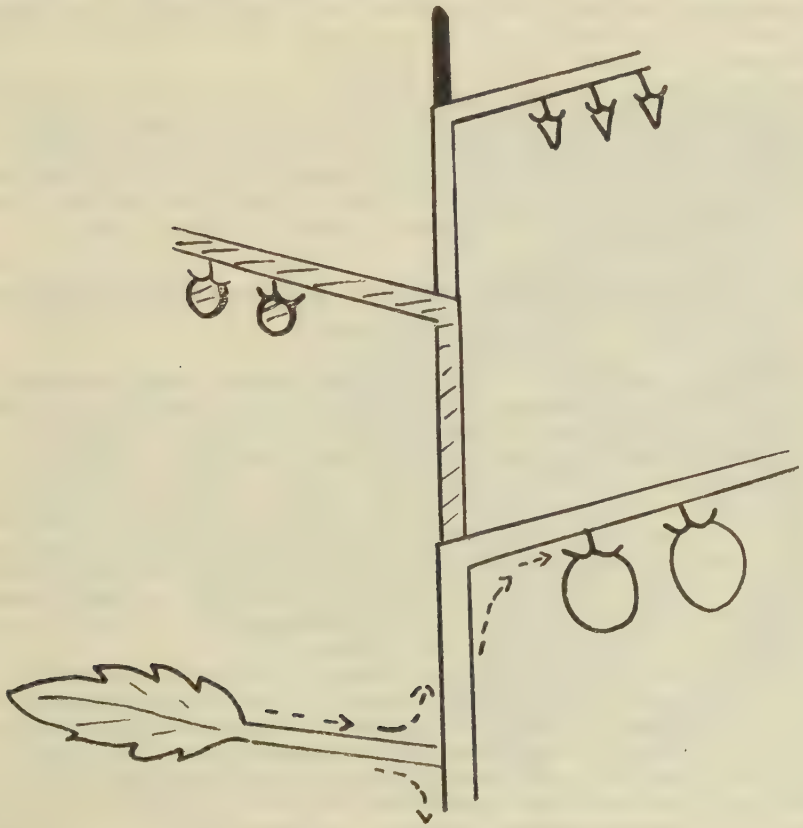


FIG. 2.—*Diagram to show successive lateral axes of a tomato plant. Sugars and viruses moving out of the leaf tend to move first to the root and fruits of the first truss of a rapidly-growing plant.*

fruits of the lowest truss, while at the same time the tops or young leaves appear to be perfectly healthy and free from any symptom of mottling. Tests made of such young leaves have proved to be negative for the presence of virus, even where the maturing fruits have been shown to contain virus.

The explanation of this result, which at first sight appears to be at variance with our accepted views concerning the invasion of the tomato plant with Tobacco Mosaic virus, would seem to be as follows:—

In a well-grown plant the main direction of flow of the food materials manufactured by the leaves will usually tend to be towards the developing fruits and the roots, and only secondarily into the young shoots of the last-formed axis. Morphologically the inflorescence terminates the main axis of the tomato plant, the main stem of the plant being made up of a succession of lateral axes (see diagram in Fig. 2). It would seem, therefore, that small numbers of virus particles may be carried with the food stream into the fruits and, providing growth conditions are such as to maintain a unidirectional flow of these materials, these virus particles may remain located in the fruit indefinitely, finally being removed from the system with the picking of the ripe fruit. Where growth and development are checked as a result of unfavourable environmental factors, stopping, etc., food materials may move out of the fruits into other parts of the plant and the virus with them.

One other important result has emerged from this work and that is that many plants which never show symptoms of mosaic infection in any part of the aerial shoots may yet contain much active virus in the roots. It thus becomes impossible to say by inspection whether any crop is completely virus-free. Following some check to development symptoms of disaese may suddenly appear in the healthiest of crops *without* the introduction of a new or recent source of infection.

For the effective functioning of mechanisms such as that envisaged above for the localisation of virus in fruits, the balance between inflorescence and stem meristems would need to be maintained in every succeeding lateral axis of the sympodium and would be dependent on satisfactory pollination and fruit development. Failure at any stage of development to keep the stream of elaborated food materials moving into the truss (or down to the roots) might result in the movement of virus from the lower leaves or from roots into the young shoots, and would presumably also result in movement of virus from its secondary location in the fruits.

To summarise the present position with regard to cultural control methods as a means of eliminating mosaic infection from the tomato crop, it is clear that the maintenance of environmental conditions to which the plant is adapted is likely to lead to the production of clean plants for the several reasons enumerated above. Until further physiological studies of factors affecting the growth of the plant have been made, it can only be stated that a rapidly growing, freely-fruiting, vigorous plant is the one most likely to be free from systemic invasion by such viruses.

5. (c) SOME UNUSUAL SYMPTOMS IN TOMATOES INFECTED WITH SPOTTED WILT

In April, 1946, specimens of tomato plants exhibiting unusual disease symptoms were collected from a nursery in Bedfordshire. A number of these plants, which were bearing from three to five trusses, were showing typical bronzing symptoms of Spotted Wilt virus infection. Others, however, showed no bronzing or spotting of the foliage. The shoot terminated, in some cases, in a flower truss and the leaflets of the young leaves were rolled upwards and were showing severe purpling on the underside of the veins (Figs. 3 and 4). In a few cases there was slight distortion of the leaflet laminae. On a number of plants showing this type of symptom, the green fruits on the lower trusses showed ring markings and distortion reminiscent of infection with Spotted Wilt. Plants with these abnormal symptoms were relatively vigorous and well-grown, being much less stunted than plants showing the typical Spotted Wilt bronzing symptoms. It could not be determined whether a late infection had occurred in the former plants.

Samples of leaf and fruit were tested for the presence of a virus by inoculating young tomato plants of *Nicotiana glutinosa* and White Burley tobacco. 0·5 per cent. sulphite solution was added to the sap and carborundum was used as an abrasive. Tomato seedlings developed symptoms similar to those of the original diseased material, but were stunted. The leaflets showed veinal purpling and uprolling, and were quite dissimilar to the typical Spotted Wilt disease. The test plants were grown on for six weeks, but no indication of either bronzing or leaf-spotting appeared. The young leaves did become distorted, however, and development of individual leaves was irregular and akin to symptoms developed during late stages of infection with the typical Spotted Wilt virus.

Leaves of *Nicotiana glutinosa* developed a few large local lesions but leaves of Burley tobacco

FIG. 3.—*Leaflet affected with "Bedford" strain of Spotted Wilt showing leaf rolling.*

FIG. 4.—*Top of affected plant from a commercial nursery. Abnormal strain of Spotted Wilt virus present.*

failed to develop any symptom. Seedling tomatoes growing in the same chamber and inoculated with a typical Spotted Wilt virus showed typical spotting and bronzing.

Further comparative tests were made in May and June and in one test it was found that of 10 tomato plants inoculated with the Bedford virus one developed a blanching of the tops, with slight veinal purpling and a few small chocolate-coloured spots on the foliage. One plant developed no leaf spots but was stunted and of a purplish hue. Eight plants failed to become infected. In this test both *Glutinosa* and Burley leaves developed large zoned local lesions.

In September a further test was made comparing "typical" Spotted Wilt and the Bedford strain. Tomato seedlings at the two-leaf stage were inoculated with juice diluted with water, with and without abrasive. No plant developed "typical" Spotted Wilt symptoms in any group, but infected plants with both strains of virus showed a blanching of the tops, leaf purpling, and general stunting. The results were as follows:—

TABLE XXVII

Treatment	No. of Plants Infected
"Typical" Spotted Wilt:	
Water only	4 out of 8
„ plus Celite	5 „ 8
„ „ Carborundum ...	8 „ 8
Bedford Strain of Virus:	
Water only	0 out of 8
„ plus Celite	6 „ 8
„ „ Carborundum ...	7 „ 8

Thus, without an abrasive, the Bedford strain of virus appeared to be less infective than the sample of "typical" Spotted Wilt.

From these experiments it was tentatively concluded that the abnormal disease symptoms had been associated with a strain of Spotted Wilt which had become slightly modified. Evidently the disease may exhibit a wide range of symptoms and careful tests may be necessary to establish the identity of the causal virus.

It may be noted that the plants in which the abnormal symptoms had been first noted were growing in a rather light soil consisting of sandy material containing powdery humus residues. An acid peat had been incorporated rather unevenly in this soil, and although a mixed sample of soil gave a pH value of 6·7, several very acid patches were found in the houses. It has been reported earlier (Ann. Rep. 1941) that a deficiency of lime in the soil may be associated with leaf rolling and purpling in tomato plants infected with Spotted Wilt. It seems possible that one factor tending to induce changes in plant viruses may be abnormal soil conditions. Meteorological factors may also play some part in changing viruses, for the blanching, leaf-purpling symptoms of Spotted Wilt have also been noted in tomato plants inoculated with typical Spotted Wilt virus in the months of December and January. They may also serve to explain the unusual result obtained with the typical Spotted Wilt strain in September in the above tests.

6. THE CONTROL OF PLANT DISEASES BY MICROBIAL ANTAGONISM

By ERNA GROSSBARD

In 1945 an attempt was made at this Station to explore the possibilities of using the antagonistic relationships between micro-organisms as a means of controlling soil-borne diseases of glasshouse crops.

Aspergillus clavatus, one of the mould fungi known to produce an antifungal and antibacterial substance named clavatin, proved to be antagonistic to certain pathogens of glasshouse crops. These investigations were continued in 1946.

Birkinshaw *et al.* found that *Penicillium patulum* Bainier produces patulin, an antibiotic substance identical with clavatin. The metabolic solution of this fungus was tested as an alternate source for clavatin. The culture of *P. patulum* Bainier, strain P.189, was kindly supplied by Prof. H. Raistrick of the London School of Hygiene and Tropical Medicine to whom we are greatly indebted.

1. The Production of an Antibiotic Substance by *Penicillium patulum* when cultured on certain Organic Media

P. patulum was grown on four different organic materials to determine if any would be a suitable medium for the production of an antibiotic substance. It was intended ultimately to use which material yielded the highest concentration of the antibiotic substance for incorporation with the soil to promote the formation of the antibiotic within the soil and thus reduce the growth of pathogenic micro-organisms.

The materials chosen were as follows:—

(*a*) Fresh wheat straw from the 1946 harvest.
(*b*) Irish sphagnum peat.
(*c*) Lawn mowings cut late in the season.
(i) One portion after being air-dried was tested immediately;
and (ii) the other allowed to decompose for three months.

After the addition of water or a 4 per cent. glucose solution respectively the media were autoclaved, inoculated, and incubated. For further details of technique see Thirty-first Annual Report for 1945.

The aqueous extract was tested for antibiotic activity against *B. coli* by the cylinder-plate method. Five cylinders, placed on nutrient agar bulk seeded with *B. coli*, were filled with the solution to be tested. After incubation the surface of the agar became covered with dense growth of *B. coli*. When the tested extract had any antibiotic activity, clear zones were found around each cylinder where bacterial growth was inhibited by the diffusion of the extract. The area in which growth was inhibited constitutes a measure of the concentration of the antibiotic.

TABLE XXVIII

The Antibiotic Activity of the Aqueous Extract of a Culture of *P. patulum* grown on four Organic Substrata

	Wheat Straw				Lawn Mowings			
	Fresh		Peat		Fresh		Decomposed	
	Water	Glucose Solution	Water	Glucose Solution	Water	Glucose Solution	Water	Glucose Solution
General Growth of Fungus	Normal	Normal	None	Normal	Normal	Normal	Normal	Normal
Inhibition	Compl.	Compl.	None	Compl.	Compl.	Compl.	None	Compl.
Diameter of Area of Inhibition (Mm.—	14	21	0	19	14	21	0	20

The results in Table XXVIII confirm those of similar experiments carried out previously with *Aspergillus clavatus*, as follows:—

(1) When the antagonist is grown upon certain plant materials such as fresh lawn mowings or wheat straw an antibiotic substance is produced, presumably clavatin, the concentration of which is increased considerably by the addition of glucose to the medium.

(2) Cultural conditions, especially those of nutrition, which encourage luxuriant growth, are not necessarily suitable for the formation of the antibiotic. Thus it was found that while the fungus grows well on decomposed lawn mowings, extracts from such cultures failed to check the growth of *B. coli* (see Table XXVIII). The addition of glucose to the decomposed lawn mowings, however, gave rise to a concentration of the inhibitory substance almost as high as that obtained with fresh lawn grass.

The manuring of soils with glucose in addition to straw or green manures is not a practical proposition. Therefore a systematic search is being made for green manures which on inoculation with the antagonist may produce an antibiotic substance of a concentration at least equal to that formed by the straw and glucose mixture.

2. The Antagonistic Activity of *Penicillium patulum* towards some Plant Pathogens

(a) Bacteria

Working with *A. clavatus* it was observed that the growth of *B. carotovorum* was inhibited by the aqueous extract of a culture of the fungus on wheat straw. The experiment was repeated with

Penicillium patulum, P.189, with similar results. Other soft rot organisms such as *B. aroideæ* and *B. phytophthorum* were also tested and found to react in the same way.

A quantitative test was made with the three soft-rot organisms by the serial dilution method, using test tubes containing Difco extract broth. The inhibiting agent was the aqueous extract of a culture of *Penicillium patulum* on wheat straw and glucose. The tubes were inoculated by adding one drop of a 1 : 100 suspension of the organism.

The cultures were kindly supplied by Dr. W. J. Dowson of the Botany School, Cambridge, to whom we are greatly indebted.

TABLE XXIX

THE SENSITIVITY OF THREE SOFT-ROT ORGANISMS TO THE DILUTED AQUEOUS EXTRACT OF A CULTURE OF *P. patulum*

Organisms	Complete Inhibition	Partial Inhibition
B. aroideæ	1 : 50	—
B. carotovorum	1 : 50	—
B. phytophthorum ...	1 : 80	1 : 100

B. phytophthorum shows the greatest degree of sensitivity to the antibiotic substance.

(b) FUNGI

Experiments carried out in 1945 with fungal pathogens indicated that *Phytophthora cryptogea* was inhibited by *Aspergillus clavatus*. *Penicillium patulum* P.189 was found to have the same effect.

Four other species, namely *P. cactorum*, *P. cinnamoni*, *P. megasperma*, and *P. parastica* (isolated at this Station) were examined for their sensitivity to *P. patulum*. The technique applied was the serial dilution method. The diluent was pea broth and the inhibitory substance the aqueous extract of a culture of *P. patulum* on fresh lawn mowings with a 4 per cent. glucose solution.

The inoculum used was a small disc taken from an eight-days-old culture of the *Phytophthora* species grown on potato glucose agar.

TABLE XXX

THE SENSITIVITY OF *Phytophthora Sp.p.* TO THE DILUTED AQUEOUS EXTRACT OF A CULTURE OF *P. patulum*

Organisms	Complete Inhibition
P. cactorum	Results inconsistent
P. cinnamoni	" "
P. cryptogea	1 : 160
P. megasperma	1 : 160
P. parasitica	1 : 320

P. cactorum and *P. cinnamoni* gave variable results and further replications are necessary before final conclusions can be drawn. *P. parasitica* is the most sentitive species.

How great are the chances of putting to practical use these antagonistic relationships between *A. clavatus* and *P. patulum* on one hand and the soft-rot bacteria and species of *Phytophthora* on the other hand cannot yet be estimated. The concentrations required for complete inhibition are high because the antibiotic is present in the culture extract in comparatively small amounts. In 1945 *P. cryptogea* was selected as the principle test organism to see if control of this pathogen by the production of crude clavatin in the soil would be possible.

3. The Effect of Aspergillus clavatus on "Damping-off"

In 1945 a small-scale experiment indicated that the incorporation with the soil of wheat straw heavily infected with *A. clavatus* may under certain conditions reduce the incidence of "damping-off" caused by *Phytophthora cryptogea*. A similar experiment has been carried out in 1946.

General Technique

Cultures of *A. clavatus* on various substrata were added to sterile virgin loam in seed trays, incubated in a glasshouse and inoculated with *P. cryptogea*. After a further period of incubation seeds were either sown in or seedlings pricked out into these boxes.

The treatments were as follows:—

(1) 1300 gm. of sterilised virgin loam mixed with 200 gm. of a sand-oatmeal culture of *A. clavatus*.

(2) Ditto and sprayed at intervals of 14 days with 300 ml. of a 4 per cent. glucose solution.

(3) 1300 gm. sterilised virgin loam mixed with 30 gm. of wheat straw heavily infected with *A. clavatus*.

(4) As in (3) but twice the amount of wheat straw, i.e. 60 gm. was added.

(5) As in (3) and sprayed every 14 days with 300 ml. of a 4 per cent. glucose solution.

(6) As in (4) and sprayed every 14 days with 300 ml. of a 4 per cent. glucose solution.

The boxes were incubated in a glasshouse under moist conditions for three weeks. After that time each box was marked into three equal sections and the centre strip was inoculated with the pathogen by adding 200 gm. of a 3 per cent. sand-oatmeal culture of *P. cryptogea*. This strip is called the "inoculated section" in Table XXXI. The purpose of this localised inoculation was to note the extent to which *P. cryptogea* would spread from the inoculated centre and thus to determine the degree of inhibition.

After a further period of incubation lasting four weeks tomato seeds were sown.

Controls were set up in a similar manner except that inoculation with *A. clavatus* was omitted.

In the first stages of the experiment no fertilisers were applied to the soil. Some plants developed symptoms of nitrogen and phosphate starvation, especially in those soils which contained glucose or straw and glucose. To these boxes were added one dressing of sulphate of ammonia and superphosphate 14 days after the seedlings emerged.

TABLE XXXI

THE PERCENTAGE OF SEEDLINGS ATTACKED BY "DAMPING-OFF" (SIX WEEKS AFTER EMERGENCE)

Substratum	Infected with *A. clavatus*			Not infected with *A. clavatus*		
	Inoculated Section	Uninoculated Section	Total per Box	Inoculated Section	Uninoculated Section	Total per Box
Soil	85·1	39·5	54·7	100·0	45·5	67·0
Soil+Glucose Solution	13·4	12·1	12·46 F	80·0	30·7	47·1 F
Soil+30 gm. Straw ...	86·1	24·5	45·0	100·0	41·9	60·2
Soil+60 gm. Straw ...	80·0	23·9	42·6	99·8	37·9	58·5
Soil+30 gm. Straw + Glucose Solution ...	94·0	6·2	35·7	99·1	31·0	53·7
Soil+60 gm. Straw+ Glucose Solution ...	10·5	47·5	35·1 F	87·0	58·8	68·2 F

F=Fertiliser: One dressing of fertiliser was added.

Results

The outstanding feature of these results was the degree of protection given by the application to the soil of glucose only, both in the treated boxes and controls. It should be noted that this protection was considerably greater in boxes containing *Aspergillus clavatus*. The results indicate that the presence of the antagonist reduced

(*a*) the spread of the disease from the centre of inoculation outwards, and

(*b*) to a lesser degree the incidence of "damping-off" within the inoculated section.

The addition of fertilisers to two treatments increased the "damping-off" rate considerably. The surviving plants responded favourably so far as their general development and growth was concerned.

Symptoms of starvation and abnormal growth were more evident among seedlings in soils inoculated with *A. clavatus*.

A similar experiment was carried out later, including two more treatments, namely:—

(1) Virgin loam was enriched with 300 ml. of a modified Czapek-Dox solution applied at intervals of 14 days.

(2) A general inoculation treatment in which the inoculum of *P. cryptogea* was mixed with all the compost in each box.

Four modifications were introduced:—

(1) Half the number of boxes received two dressings of sodium nitrate and superphosphate prior to pricking out, except the Czapek-Dox treatment.

(2) The inoculum of *P. cryptogea* was doubled and in the localised inoculation set it was not mixed with compost. The sand-oatmeal culture constituted the centre strip.

(3) The double quantity of straw, namely 60 gm. per box, was used throughout the whole straw treatment.

(4) Seeds were not sown directly into the experimental soils but seedlings were raised under commercial conditions and pricked out into each experimental box on November 29th. See Table XXXII.

Results

Where a localised inoculation was made all seedlings in both, treated boxes and controls, died off in the section containing the inoculum. Results are therefore given only for the sections into which the disease has spread from the centre of inoculation, while in the general inoculation set results are given as the total for the whole box.

TABLE XXXII

The Percentage of Seedlings attacked by "Damping-Off" (Eight Weeks after Pricking Out)

Substratum	Infected with *A. clavatus*				Not infected with *A. clavatus*			
	Local Inoculation		General Inoculation		Local Inoculation		General Inoculation	
	Fertiliser added	None	Fertiliser added	None	Fertiliser added	None	Fertiliser added	None
Soil	61·0	100	100	100	63·9	84·7	100	100
Soil+Glucose ...	70·8	70·0	98·1	100	55·5	73·6	100	100
Soil+Straw ...	40·3	34·9	100	100	79·2	72·2	100	100
Soil+Straw+ Glucose	34·9	66·6	100	100	44·4	58·3	100	100
Soil+modified Czapek-Dox ...	—	47·2	—	100	—	66·6	—	100

The attack of "damping-off" proved to be very severe. The results of the general inoculation sets were entirely negative. Among the localised inoculation sets the straw and Czapek-Dox treatments gave rise to some reduction in the spread of the disease, while the "glucose only" treatment stimulated rather than controlled "damping-off" more so in soils inoculated with *A. clavatus*.

Unlike sulphate of ammonia, sodium nitrate showed no ill effects. With a few exceptions "damping-off" was less severe. There was no difference in the general appearance between plants in the treated and control sets.

Summary

The investigations of antibiotic substances in relation to the control of soil-borne diseases has been continued.

A second source of *clavatin*, namely *Penicillium patulum*, has been studied. Grown on such organic media as are suitable for incorporation with the soil an antibiotic substance, presumably clavatin, was produced under certain conditions, one of which was the presence of glucose. *P. patulum* was found to be antagonistic to three soft-rot organisms and to several species of *Phytophthora*.

Further trials were carried out on the retarding effect of *Aspergillus clavatus* on "damping-off" of tomato seedlings. Although results were not always consistent, indications have been obtained that under certain conditions the rate of spread of the disease may be reduced in soils inoculated with the antagonist.

III. ANIMAL PESTS

1. RED SPIDER MITE (*TETRANYCHUS TELARIUS* L.)

By E. R. SPEYER and W. J. PARR

Some preliminary observations have been recorded upon the effect on the mite of azobenzene delivered as an aerosol from a spray gun in an experimental glasshouse of 2,000 cubic feet capacity into which infested carnations growing in pots had been introduced.

16 grs. azobenzene dissolved in 112 c.c. acetone were thus liberated on the morning of 17th October. During the ensuing three hours, the range of temperature was 62° F.–66° F. and of relative humidity 80–90 per cent. At the termination of this period, large numbers of mites, including young stages even in the 1st instar, were found to be hanging from the foliage upon strands of webbing.

These and other mites upon the foliage appeared to be unable to co-ordinate the movements of their legs, and were either unable to walk, or, having progressed for a short distance, soon came to rest; there were constant twitching movements of the appendages.

Some of the mites were collected at random and kept under observation in glass-top boxes.

(*a*) Two males, nine females, and eight immature mites were placed upon a carnation leaf from the fumigated glasshouse. After a period of 18 hours, one male, seven females, and five young appeared to have recovered their normal activity, but during the next 24 hours all except one female became moribund, and three mites in the 1st instar died. Upon the fourth day after treatment, only two females showed signs of life by feeble twitching of the legs.

(*b*) Fifteen females and six immature mites were transferred to a fresh tomato leaflet. After 18 hours, only one female (teneral) and one male in the 3rd instar showed no signs of movement, and the majority appeared to have recovered, but subsequently they gradually died off, until, on the seventh day after treatment, only two females which had assumed the red colouration of the hibernating form, showed any sign of movement. These succumbed upon the following day.

(*c*) Infested leaves were collected from the glasshouse 24 hours after the fumigation. Many mites continued to show considerable activity upon the following day, but later became moribund, and on the seventh day after treatment all the males and immature mites were dead or moribund, and of the very large number of females, only one was alive, and had deposited a few eggs.

During the course of these observations, infested carnation leaves collected from an adjoining glasshouse were kept under exactly similar conditions; the mites upon them remained active and the females laid large numbers of eggs.

It would appear that azobenzene, distributed in this manner, kills the mites slowly, and possibly through absorption by the integument. During a period of some two days after treatment, some of the mites seemed to recover temporarily from the initial paralysis induced. This was not due to the solvent, for in a separate experiment it was found that the vapour of acetone, at comparatively high concentration in the atmosphere, had a transient anæsthetic action upon the mite.

It should be recorded that on the seventh day after the fumigation, large numbers of active female mites were found to be present upon a blade of oryza growing vertically from the soil of one of the pots. Doubtless the mites, after falling to the soil-surface from the carnation foliage had ascended the blade, upon which they later bred prolifically. No explanation can at present be offered for the survival of these mites, for, as far as it was possible to ascertain, no mites were alive upon the carnation plants a fortnight after the fumigation was carried out. Some light, however, may be thrown upon the occurrence through some simple laboratory experiments now to be described.

Toward the end of October some attempt was made to enquire, under laboratory conditions, into the reaction of living mites to azobenzene, and into the effect of this compound upon the tissues of the mite. Hibernating mites collected from tomato foliage or from crevices in the stems of old tomato plants were employed in experiments carried out at room-temperature roughly between 60° F. and 75° F. The mites were introduced into small glass tubes about 2 ins. long and $\frac{1}{2}$ in. in diameter; in these they could be observed under a binocular microscope.

Experiment 1

In order to observe their reactions to the vapour of azobenzene, two colonies of respectively seven and eight mites were excised in situ from a crevice and each introduced into a tube, the ends of which were covered with fine muslin. The tube containing the former colony was enclosed in a glass-top box (3ins. diameter, and 1 in. depth) and served as a control: that containing the latter colony in a similar box upon the floor of which was laid a filter paper saturated with azobenzene (effected by soaking the paper in a 10 per cent. solution in acetone, which was allowed to evaporate). Both boxes were kept in the dark. During the first two days the mites did not appreciably change their positions, and on exposure to sunlight for a few minutes those in both tubes began to move about upon the small piece of plant tissue on which they were situated. On the following morning all but two of the mites in the untreated box had dispersed to the ends of the tube; those in the box containing azobenzene had not dispersed and only one mite moved slightly when the colony was exposed to the sunlight. On the sixth day after the experiment was started, all the mites in the untreated box were alive and moved actively when immersed in a preservative (Bouin's Picroformol): of the eight mites in the box containing azobenzene all were motionless, but four made feeble movements with their legs when transferred to the preservative.

Experiment 2

(*a*) With a view to bringing mites into contact with a surface thinly coated with the compound, a tube open at both ends was dipped in a 1 per cent. solution of azobenzene in acetone and allowed to dry. Three mites introduced into the tube, the ends of which were later covered with muslin, made violent movements and then rapidly became paralysed: all were dead when examined 18 hours later. Mites kept similarly in an untreated tube were alive and active at the end of this period. It was noted that the inside of the treated tube was not uniformly covered with the azobenzene which had tended to accumulate here and there into droplets of varying size upon the glass.

(*b*) Twenty-four hours later, after a certain amount of the azobenzene might be presumed to have volatilised, four mites were introduced into the same tube. There appeared to be no immediate action upon them. After 18 hours one had ceased to move, one was hanging upon a strand of webbing, and the other two were active, though possibly showing lack of co-ordination in movement of the legs. Six hours later, all were motionless and were then removed to a fresh tomato leaflet. Four days later, only one was able to move its legs freely.

(*c*) To observe their reactions both to the vapour of and when coming into contact with the compound, a colony of six mites was introduced in situ upon a piece of tomato stem into a tube which had been dipped into a 1 per cent. solution of azobenzene in acetone and dried. After 18 hours, three mites had moved on to the glass and were motionless: the other three, only one of which showed signs of movement, had remained upon the piece of stem.

Experiment 3

The reactions to a comparatively high concentration of the vapour in the atmosphere was observed by introducing four mites into a tube plugged at one end with cotton-wool: the other end was then plugged with a wad of wool which had been dipped in a 1 per cent. solution of azobenzene in acetone and dried. The mites immediately ran rapidly over the glass and spun webbing: soon after, their activities ceased and were reduced to twitching movements of the legs. When examined 18 hours later all were motionless, still hanging upon their webs. They were now removed to a fresh tomato leaflet and on the following day three were still motionless, but the fourth made unco-ordinated movements of the legs, which were still apparent three days later.

Experiment 4

To observe the effects of placing mites upon the surface of a substance impregnated with the compound, 40 mites were dropped on to a sheet of paraffin wax (M.P. 56° C.) in which azobenzene had been dissolved at the rate of one part to 100 parts wax. After 24 hours, the majority of the mites had wandered off the sheet, but the 11 which had remained upon it showed much activity, and were removed to a fresh tomato leaflet. They gradually died off, and upon the ninth day after their removal from the wax sheet, there was only one active survivor.

From the results obtained, it would appear that, in an atmosphere in which the vapour of azobenzene might be presumed to have diffused rapidly (see Experiments 2(*a*) and 3), the mites exhibited signs of great irritation, which induced them to spin webbing. This was reminiscent of the effect of naphthalene vapour upon the mite. In an atmosphere into which the vapour might be presumed to have diffused more or less gradually (see Experiments 1 and 2(*c*)), the irritant action was not produced, and death of the mites ensued only after a comparatively long period of time,

possibly as the result of condensation of the compound upon the cuticle and gradual penetration into the internal organs. The mites did not immediately react on contact with small amounts of solid or semi-solid azobenzene (see Experiments 2(*b*) and 4): there may have been adsorption upon the cuticle, which was only slowly permeated by the compound.

It therefore seems possible to visualise the effect of a glasshouse fumigation in which azobenzene has been liberated in the manner previously described. An immediate high concentration of vapour in the atmosphere induces the mites to spin, and hang from the foliage upon strands of webbing: many of them fall to the ground, where they may be protected from the condensed vapour and survive if they can later gain access to any vegetation upon which the compound has condensed in quantity insufficient to cause their death by contact.

Microtome sections of mites exposed to the action of azobenzene in the experiments described, show the presence of deeply staining rounded and oval bodies of varying size in the cells lining the lumen of the combined hind-gut and excretory organ, which for the greater part of its length lies closely beneath the cuticle of the dorsal surface. A precisely similar condition, however, has been found in some mites not so treated.

Though it is possible that degeneration of this organ may be a natural occurrence during the period of hibernation, it is more probable that the condition marks the first phase of general disorganisation of tissues prior to death, whether natural or caused by the action of poisons. It is known that many mites, after assuming the red colouration immediately prior to hibernation, do not survive the winter.

Further investigation is in progress.

2. WHITE-FLY (*TRIALEURODES VAPORARIORUM* WESTWD.)

By E. R. SPEYER and W. J. PARR

(a) Observations upon the Habits of Adult Flies

In the course of some spraying experiments with DDT to be described later, adult flies intended to serve as controls in the laboratory were liberated in large muslin-covered glass jars, containing freshly-cut tomato leaves. Considerable numbers of these flies died within a comparatively short period of time after their introduction into the jars. Thus, of 146 flies introduced on 24th July, eight were dead within 24 hours, and upon the eighth day 91 had succumbed, leaving only 55 alive: of 71 flies introduced on 2nd August, 15 were dead within 24 hours, and all had succumbed by the fourth day.

It appeared that the mortality might be due to the flies being unable to obtain sufficient moisture from the cut foliage. In further trials, therefore, the stalks of the leaves were kept immersed in water with the following results:—

Of 145 flies introduced, many were dead within 24 hours, and none remained alive after two days: in another jar, of 179 flies, 36 were moribund or dead within 24 hours, and only 28 were still alive after two days. Lack of moisture was therefore not the cause of the high mortality.

On 1st August tomato leaves upon which pupæ in an advanced state of development were present were cut from a plant and kept with their stalks in water. Adult flies began to emerge after two days, but on 6th August 70 dead were counted, and though many were alive four days later, 378 more had died.

It was noted throughout that the flies were averse to resting upon the foliage, and tended to congregate upon the inside of the muslin covers or sides of the jars immediately beneath them.

In order to observe the effects of lack of moisture and food on a smaller scale, flies were introduced into wide-mouth bottles covered with muslin.

In the first bottle, neither food nor moisture were provided, and the insects succumbed within 24 hours. In the second a wad of moist cotton-wool was placed at the bottom; of the many flies introduced a few died within 24 hours, but only six were alive after 48 hours and all were dead by the third day. The third bottle contained fresh tomato leaflets taken from high up upon a plant, and 37 flies were liberated: only one of them succumbed within 24 hours, five more within 48 hours, and no further deaths had occurred by the third day, but on the sixth only seven flies remained alive.

Presence of moisture had therefore slightly increased the length of life, and food obtainable from young foliage, even after its removal from the plant, enabled some of the flies to survive for a much longer period of time.

As the flies under natural conditions are known to collect, often in vast numbers upon the foliage around the growing point of plants which they infest, it may perhaps be concluded that they are dependent upon a more or less continuous supply of nutriment (possibly in the form of sugars)

which is not available to them in sufficient quantity in older leaves which have been severed from the plant.

LL. Lloyd (1922, Ann. Appl. Biol. IX, No. 1, p. 18), in his account of the insect, states that a greenhouse may be cleared of the pest completely by removal from it of all vegetation and by keeping on heat for a period of one week.

(b) Spraying Experiments with DDT

Sprays containing DDT were applied by means of a power sprayer to tomato plants of the variety Potentate, 4 ft. tall, grown in the ground in a glasshouse 25 ft. by 15 ft. White-flies had been liberated in the house early in April, and a severe infestation had developed when the first applications were made on 21st June.

(i) To the plants on one side of the house a 14 per cent. suspension and to those on the other a proprietary 20 per cent. emulsion were applied respectively, both having been diluted to give a concentration of one part DDT to 4,000 parts water.

All adult flies were killed by both sprays.

As soon as the spray fluid had dried upon the foliage, a leaf upon which pupæ were present was cut from a plant on each side of the house and kept with its stalk in water under a lamp-glass covered with muslin. During the ensuing period of seven days many flies emerged from the pupæ; the majority lived for only a few hours, but upon the seventh day a few were alive on each leaf.

Four days after application of the sprays, many "scales" in the 1st and 2nd instar upon foliage round the growing point of the plants were found to be dead and shrivelled. A fortnight after application adult flies were emerging from pupæ upon the lower leaves of the plants.

The results obtained indicated that both suspension and emulsion had killed the adult flies and a large number of scales at the time of application, but that a considerable number of the latter and the pupæ had escaped destruction. It appeared that the residue left by the sprays upon the foliage had retained its lethal action on flies emerging from pupæ for a period of about one week.

(ii) Three weeks after the sprays had been applied, a considerable infestation had again developed upon the plants, incremented by flies entering the house from an adjoining partition which had been fumigated with tetrachlorethane at the rate of 8 ounces per 1,000 cubic feet space on 13th June.

On 12th July the plants were again sprayed, but now the concentration of the suspension was increased to one part DDT in 2,000 and that of the emulsion to one part DDT in 1,000 parts water: the plants in the adjoining partition were also sprayed in order to reduce the chances of contamination.

Upon the following day dead adult flies covered the foliage and soil surface and no living ones could be found. Pupæ were again kept under observation upon leaves cut from sprayed plants: during a period of 12 days, 177 flies emerged from those upon a leaf sprayed with the suspension, and 242 upon a leaf to which the emulsion had been applied. These flies appeared to remain alive for a much shorter period of time than those which emerged from pupæ on an unsprayed leaf kept under similar conditions as a control, but further details are not given for reasons referred to above (see Section 2(a)).

It was estimated that flies settling upon the foliage were killed by the residue left by both suspension and emulsion for a period of not less than 12 days after application of the sprays.

(iii) Tomato pot-plants of the variety Potentate, 5 ins. in height, upon the foliage of which white-flies had deposited eggs, were sprayed with the suspension containing 0·05 per cent. DDT and the emulsion 0·1 per cent. DDT on 12th July. After treatment, the plants were kept in separate cages, and into a third cage similar plants sprayed with water were introduced to serve as a control. As far as it was possible to judge, by close examination, eggs laid by the flies had been distributed fairly evenly amongst all the plants.

Upon selected leaves which had been marked with labels, all the eggs hatched between the third and sixth day after application of the sprays. Young scales upon the sprayed foliage appeared to be healthy, but on the eighth day after treatment the majority of those upon the leaves sprayed with the suspension were dead, while a considerable number on those to which the emulsion had been applied were alive. The scales upon the control plants were developing normally.

On the nineteenth day after treatment, the surviving scales had reached the 3rd instar, and some were already in the pupal stage. Counts of those upon leaves removed from the plants gave the following results:—

Sprayed with suspension	...	8	scales	on	7	leaves—average	1	per leaf
Sprayed with emulsion	...	543	„		12	„ „	45	„
Control	...	1172	„		12	„ „	98	„

From these observations, it became evident that neither eggs nor pupæ, both of which are thickly coated with waxy secretion, were killed either by the suspension or the emulsion, in each of which the concentration of DDT was comparatively high. A far greater proportion of young scales, shortly after hatching from the egg, appeared to have been destroyed by the spray residue in the case of the suspension than in that of the emulsion, the latter of which contained twice the amount of DDT.

(c) Rhubarb as a Deterrent

From time to time reports have been received intimating that white-fly infestations have disappeared from the plants in glasshouses and frames after rhubarb plants have been introduced into them.

In the glasshouse in which the spraying experiments described above were later carried out, six rhubarb roots were set out in the ground on 8th April, three on each side at equal intervals from one another between rows of tomatoes, 3 ft. apart, planted out at the same time.

Four days later large numbers of adult flies were liberated in the house.

By the beginning of May, the rhubarb plants had developed leaves of large size: adult flies were confined almost entirely to the tomato plants, and when disturbed seldom settled upon the rhubarb leaves, on which no eggs appeared to have been laid. Scale stages of the fly were in abundance upon the foliage of the tomato plants, and it was noted that large numbers were present upon leaves which were in close proximity with or actually touching those of the rhubarb.

In June a very severe infestation developed upon the tomatoes, quite as severe indeed as upon others of the same age growing in an adjacent partition in which no rhubarb had been grown. The number of rhubarb plants to the area and the space occupied by them far exceeded that which could possibly be utilised economically in commercial glasshouses or conservatories, and it was concluded that in the cases reported, the cause of disappearance of the pest had been other than that to which it was attributed.

3. WHITE-FLY PARASITE (*ENCARSIA FORMOSA* GAHAN)

By E. R. SPEYER and W. J. PARR

When sprays containing respectively 0·05 per cent. DDT in suspension and 0·1 per cent. DDT in emulsion were applied to tomato plants on 12th July, a small proportion of white-fly scales upon the foliage had become parasitised by Encarsia and had turned black. No emergence of adult parasites from these scales took place during the period of one month while they were kept under observation. From black scales upon unsprayed leaves kept under similar conditions, adult parasites continued to emerge from the third to the fourteenth day after the leaves had been removed from the plants, and emergence was practically complete.

The concentration of DDT in the sprays employed was comparatively high, but it is evident that this insecticide may be extremely destructive to the parasite, which is contained within the integument of the white-fly scale before the latter has become thickly coated with waxy secretion.

4. TOMATO MOTH (*DIATARAXIA OLERACEA* L.)

By E. R. SPEYER and W. J. PARR

In his account of the Life-history and Habits of the Tomato Moth, Ll. Lloyd (1920 Ann. Appl. Biol. VII, No. 1, pp. 72–77) described experiments, carried out in that year, the results of which showed that the caterpillars of this insect were, as a rule, unable to complete their development when reared upon an unvaried diet of tomato foliage. The variety of tomato employed in his experiments was Comet. This applied not only to young larvæ but to those which had hatched from the egg two to three weeks previously, during which their diet had been varied.

He suggested that the high mortality amongst these caterpillars might be due either to a deficiency in tomato foliage of some substance (possibly a vitamin) essential to their development, or to the presence in the tissues of the plant of a poison to which some larvæ were more susceptible than others.

During recent years the habits of the caterpillars in the experimental houses at Cheshunt appear in this respect to have undergone a change.

Larvæ reared from the egg in the laboratory at a mean temperature of 66° F. during April, 1944, were fed upon leaves of the variety Potentate, and when given a choice between these and leaves of Polygonum (a much favoured food-plant), showed such a preference for the former that the latter remained practically and in most instances entirely untouched. They completed their

development to the pupal stage in from 33–39 days, as compared with Lloyd's recorded period of 37–44 days on Comet, and 28–34 days on Chenopodium or Polygonum at the same mean temperature.

In 1946 plants of Comet were grown at Cheshunt with a view to determining whether or not this old variety of tomato was deficient in, and the more recent Potentate replete with the essentials necessary for successful development of the caterpillars.

On 13th June, 17 larvæ in the 1st to 3rd instar were collected from the variety Cooper's Ideal and provided only with foliage of tomato. Of nine larvæ fed upon Comet, five developed in from 15 to 27 days to pupæ, from all of which moths emerged between 28th July and 1st August. Of the other eight caterpillars fed upon Potentate, six became pupæ in from 17 to 30 days: two of the latter emerged on 29th July, and the remainder were of the "long-period" type.

In both instances the degree of mortality was no greater than that to be expected amongst larvæ of this age irrespective of the diet provided.

Older caterpillars in the 4th to 6th instars were at the same time collected at random from different varieties of tomato in the experimental houses.

Of nine fed upon Comet, eight developed successfully in from nine to 17 days to pupæ, all of which emerged as moths between 10th and 21st July.

Of eight fed exclusively on Potentate, all developed in from 12 to 17 days to pupæ, five of which emerged between 12th and 28th July, the remainder being of the long-period type.

The high proportion of caterpillars which developed successfully both upon an unvaried diet of Comet and of Potentate suggests either that conditions of cultivation under which tomato plants are now grown has effected a change in the composition of the foliage and thus provided the caterpillars with their full nutritional requirements, or that a race of the Tomato Moth has arisen through gradual selection over a number of years, the caterpillars of which show a high degree of resistance to a poison contained in the foliage of tomato plants. The latter supposition would appear to be the more probable, for certain races of Codling Moth and of other insects are known, in which a general inherited resistance to poisons has been acquired through the action of selection.

5. WOODLICE

By E. R. SPEYER and W. J. PARR

In order to observe the action of DDT upon the Cucumber-house Woodlouse (*Armadillidium speyeri* Jackson), experiments were carried out on a small scale in the laboratory during February and March.

(1) DDT as a Contact Poison

(*a*) Fourteen woodlice were kept for 30 minutes in a glass dish, to the interior of which a 5 per cent. DDT powder had been applied, and were then transferred to a vessel containing soil. Four days later, six were found to have died and eight were alive and active.

(*b*) Twenty-seven woodlice were kept for seven days in a vessel containing soil, the surface of which had been dusted with a 5 per cent. DDT powder. At the termination of this period, 20 were found to be dead, and the remaining seven alive and active.

(*c*) Twenty-eight woodlice were kept for seven days in a vessel containing soil which had been thoroughly mixed with a 5 per cent. DDT powder, at the rate of one part powder to 100 parts soil. At the end of this period 14 were dead and 14 alive and active.

As a control for these experiments, 28 woodlice were kept for seven days in a vessel containing soil: during this period only one died.

It was concluded that DDT was uncertain in its action as a contact poison, but that a fairly high proportion of the woodlice might be destroyed if the animals came into contact with a 5 per cent. DDT powder, dusted upon the soil surface.

(2) DDT as a Poison in Baits

In this series of experiments, the woodlice were introduced into dishes containing soil upon the surface of which the baits were later distributed as evenly as possible. The mortality amongst the woodlice was recorded daily over a period of seven days. To secure a standard of comparison, baits containing Paris Green were used under exactly similar conditions, and as controls bran or dried blood without additions of poisons.

(*a*) Dry bran 100 parts: pure DDT one part.
Eighteen out of 24 woodlice were killed: no deaths occurred during the first two days.

(*b*) Dry bran 100 parts: 5 per cent. DDT powder one part.
Ten out of 24 woodlice were killed: no deaths occurred during the first two days.

(*c*) Dry bran 28 parts: Paris Green one part.
Thirteen out of 24 woodlice were killed: nine of them succumbed during the first 24 hours.

(*d*) Dry bran, as control.
All 24 woodlice were alive after seven days.

(*e*) Dried blood 100 parts: pure DDT one part.
Seventeen out of 24 woodlice were killed: no deaths occurred during the first 24 hours.

(*f*) Dried blood 28 parts: 5 per cent. DDT powder one part.
Ten out of 50 woodlice were killed: no deaths occurred during the first two days.

(*g*) Dried blood 56 parts: Paris Green one part.
Twenty-four out of 25 woodlice were killed: 14 of these succumbed during the first 24 hours.

(*h*) Dried blood, as control.
One out of 25 woodlice died upon the sixth day.

From the results of these experiments it would appear very probable that the DDT used in the baits acted as a contact rather than as a stomach poison.

As a means of destroying woodlice, a higher mortality was obtained with a bait composed of one part pure DDT to 100 parts bran (*a*), than with one part Paris Green to 28 parts bran (*c*); but in consideration of the fact that some woodlice might not be feeding during the course of the experiment, the difference cannot be taken as significant.

On the other hand, the standard bait composed of one part Paris Green to 56 parts dried blood (*g*) was far more effective than any other of those employed.

6. TOMATO LEAF-MINER (*LIRIOMYZA STRIGATA* MACQ.)

By E. R. SPEYER and W. J. PARR

In an account of this insect given in 1944 (Thirtieth Annual Report, pp. 41–52) reference was made (loc. cit. p. 53) to injury to tomato seedlings caused by the removal by the larva of tissue from the cotyledons, and to similar injury which might be expected to arise if cotyledons were cut from seedlings as a means of controlling the pest.

A more detailed investigation upon the effect of removing cotyledons at varying intervals of time after germination of the seed has since been undertaken.

A preliminary experiment, carried out in May, 1945, when higher temperatures than usually obtain during the propagating season prevailed, indicated that growth both of the aerial portions and of the roots was greatly retarded when the cotyledons had been removed from three to nine days after germination. Further, the foliage of plants so treated appeared to develop very marked symptoms of phosphate deficiency at least for some weeks during their subsequent development.

In this experiment, seed of the variety E.S.1 was sown on 14th May in boxes containing steamed soil (five parts maiden loam with one part rotting horse manure) to which lime was added at the rate of one "60" size pot per barrowload. The seed germinated on 20th May.

Cotyledons were cut from 18 plants, then about ½ in. in height, on 23rd, from 20 plants about 1 in. tall on the 26th, and from 18 plants about 1½ ins. tall on 29th May. On 31st May six plants from each series, and six from which the cotyledons had not been removed, were potted in soil similar to that used in the seed-boxes, but with superphosphate added at the rate of one "60" size pot per barrow of soil.

TABLE XXXIII

After Germination	Twenty-three Days		Thirty-seven Days	
Cotyledons Cut	Height (ins.)	Root-length (ins.)	Height (ins.)	Root-length (ins.)
Three Days	1·6	1·5	4·5	6·7
Six „	2·1	2·6	5·2	7·0
Nine „	2·7	4·4	8·8	9·3
Control	3·9	6·6	9·9	10·5

The figures in Table XXXIII give the average height of six plants and the mean root length of two plants in each series on the twelfth day after potting up, and similar averages for four plants in each series on the twenty-sixth day after potting up.

The hours of sunlight recorded were as follows:—

20th to 31st May	... ...	63·5 : daily average 5·8
1st to 12th June	... ...	70·9 : „ „ 5·9
13th to 26th June	... ...	118·6 : „ „ 8·5

No claim is made for accuracy in recording the height, which was measured from soil level to apex of growing point, and the length of roots, but when compared with the untreated control, the figures suggest that there had been a correlation between the time after germination at which the cotyledons were removed and the degree of retardation in development of the seedlings. The roots of all the plants, whether retarded or not, had a healthy appearance.

Between a period of 23 and 37 days after germination, there appeared to be a tendency for the foliage of the plants from which the cotyledons had been cut to regain their normal appearance.

It should be added that on 12th June (12 days after potting) superphosphate, at the rate of 2 grs. to each pot, was watered into the soil of the pots containing the tallest and the shortest plant in each series and in the control, but the addition did not appear to have any marked effect in promoting growth.

During the early months of 1946, an experiment of a similar nature but upon a more extensive scale was arranged, especially with a view to determining if addition of superphosphate to the soil would tend to restore seedlings from which the cotyledons had been removed to their normal rate of development. This was carried out in the glasshouse in which plants were being propagated for the experimental houses at Cheshunt.

Seed of the variety Potentate was sown on 22nd January in boxes containing soil of composition similar to that used in the previous experiment, but with the addition of one "60" size pot of superphosphate per barrow-load, this amount being referred to hereafter as "normal."

The seed germinated on 2nd February—11 days after sowing, and the seedlings were potted in "60" size pots on 18th February—16 days after germination.

The outlay of the experiment is illustrated in Table XXXIV, in which the height of the plants at the time of treatment and of potting up is also recorded.

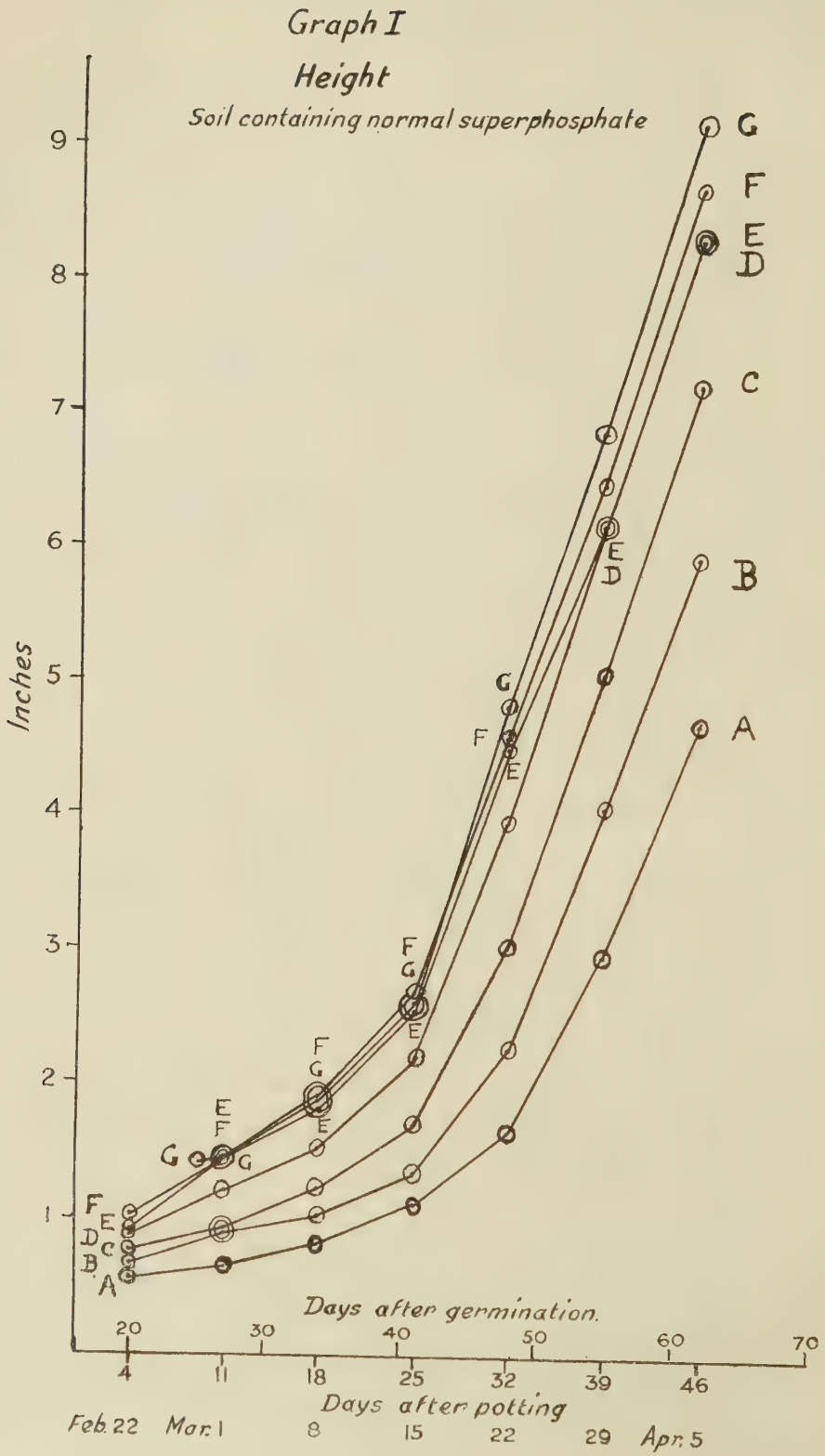
TABLE XXXIV

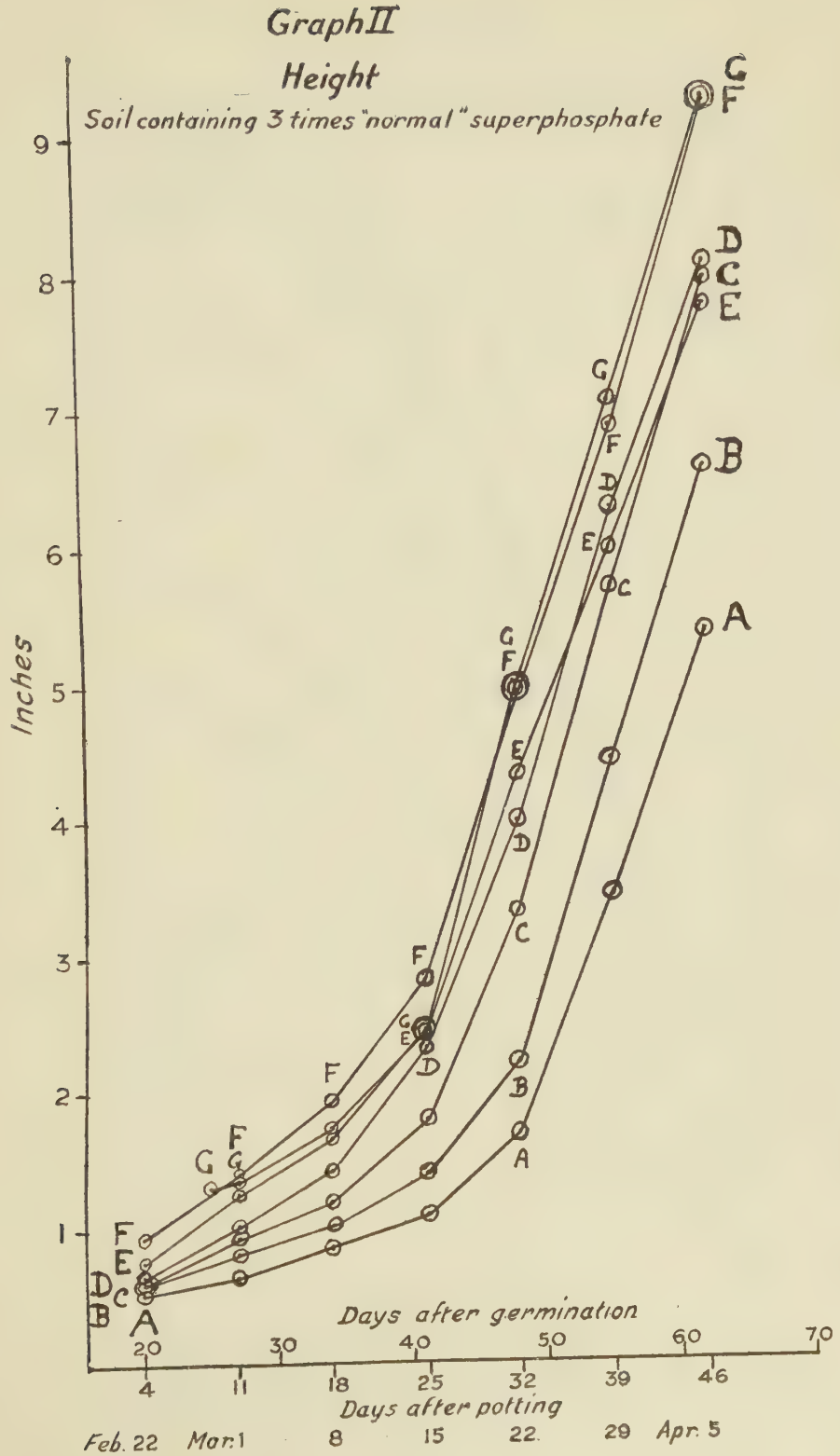
Series		Cotyledons removed after Germination	Average Height in Inches	
			At Time of Treatment	At Time of Potting
Plants in Seed-box	A	4 days	0·9	1·0
	B	7 „	1·1	1·1
	C	11 „	1·25	1·3
	D	14 „	1·4	1·4
	E	Control (untreated)	—	1·4
Plants in Pots	F	20 days	0·99	—
	G	25 „	1·36	—

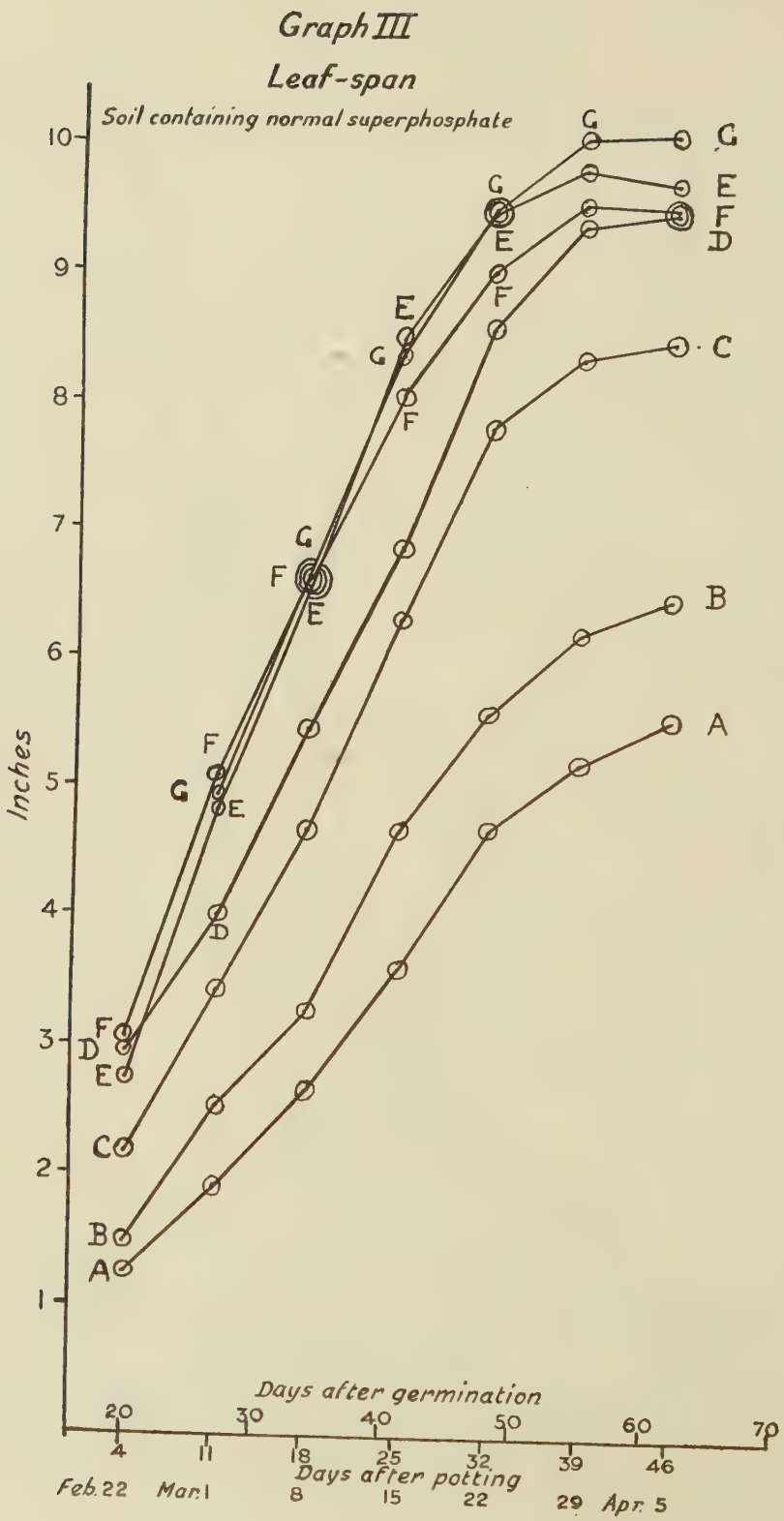
There were 10 plants in each of the series A to G, and at the time of potting, each was separated into two groups respectively of six and four plants: the former were grown in soil (as previously) containing the normal amount, and the latter in soil containing three times the normal amount of superphosphate.

It will be noted from the figures in Table XXXIV that the plants of series A, B, and C, made no appreciable growth during the periods of respectively 12, nine, and five days during which they remained in the seed-box after the cotyledons had been removed from them.

The height, measured from soil level to apex of growing point, and the maximum span of the first two rough leaves of all the plants were recorded at weekly intervals from 22nd February, four days after potting up, until 5th April, when the untreated control plants were ready for planting out in the ground. The average measurements of height for the plants grown in soil containing the normal and three times the normal amount of superphosphate are plotted respectively in Graphs I and II; those of leaf-span in soils with corresponding amounts of superphosphate in Graphs III and IV.


Graph I
Height
Soil containing normal superphosphate
Inches
9
8
7
6
5
4
3
2
1
G
F
E
D
C
B
A
Days after germination.
20
30
40
50
60
70
4
11
18
25
32
39
46
Days after potting
Feb. 22
Mar. 1
8
15
22
29
Apr. 5

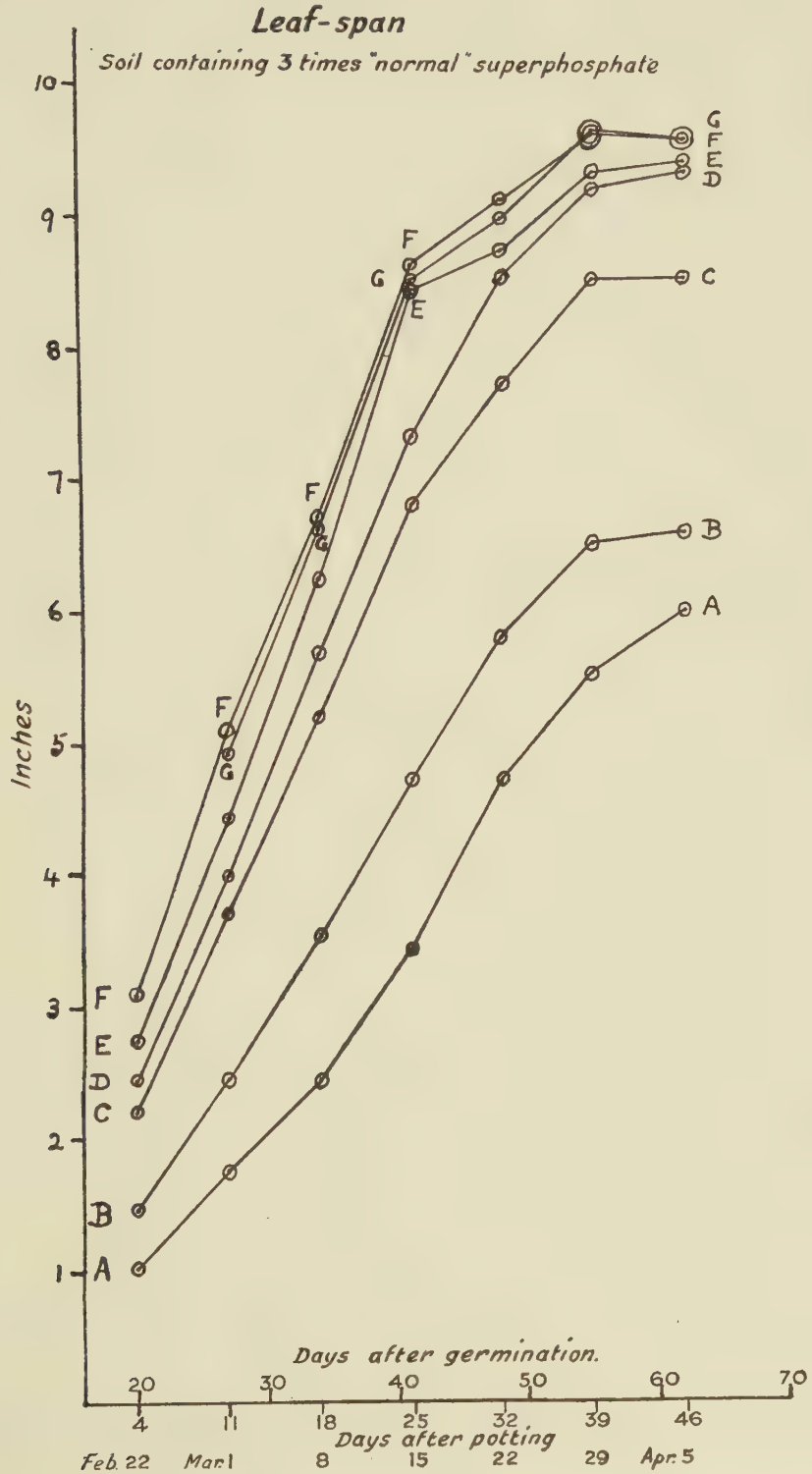

Graph II
Height
Soil containing 3 times "normal" superphosphate
Inches
9
8
7
6
5
4
3
2
1
Days after germination
20
30
40
50
60
70
4
11
18
25
32
39
46
Days after potting
Feb. 22
Mar. 1
8
15
22
29
Apr. 5
A
B
C
D
E
F
G


Graph III
Leaf-span
Soil containing normal superphosphate
Inches
10
9
8
7
6
5
4
3
2
1
A
B
C
D
E
F
G
Days after germination
20
30
40
50
60
70
4
11
18
25
32
39
46
Days after potting
Feb. 22
Mar. 1
8
15
22
29
Apr. 5

Graph IV

Leaf-span

Soil containing 3 times "normal" superphosphate



The difference in the shape of the curves for growth in height and increase in leaf-span may be due partly to natural limitation in lateral growth of the leaves, and partly to the functions of the first rough leaves being taken over gradually by the newly-formed foliage above them.

The parallel curves for plants in the series A, B, and C clearly illustrate the degree of retardation in height, and to a still greater extent in leaf-span, which was effected by removal of the cotyledons at four, seven, and 11 days respectively after germination. Furthermore, the degree of retardation is seen to be directly proportional to the period of time after germination at which the cotyledons were removed.

Comparison of the curves for the corresponding series in Graphs I and II shows that growth in height has been retarded to a lesser degree in soil containing excess superphosphate, the plants of series C in Graph II having eventually almost caught up with those of E, the control.

Comparison between the corresponding series in Graphs III and IV indicates that the growth of the rough leaves has not been thus accelerated by excess superphosphate in the soil.

In series D, from the plants of which the cotyledons were removed 14 days after germination, there has been some initial retardation of growth in height, but later the seedlings have caught up with, and in soil containing excess superphosphate, have outgrown those of series E, the control.

Increase in leaf-span for the plants in series D has been retarded to a somewhat greater extent, though the final measurements do not differ significantly from those of the control: here again, excess superphosphate in the soil has not accelerated growth of the rough leaves.

The growth in height of the plants in series F and G, appears to have been stimulated by the removal of the cotyledons after potting up, especially in soil containing excess superphosphate, but the measurements recorded for height and leaf-span may not differ significantly from those of the controls.

It is important to add that none of the plants at any time gave visual indication, as judged by the colour of the foliage, of mineral deficiency such as had been observed in the previous experiment. The absence of these symptoms is probably attributable to the lower temperatures and fewer hours of sunlight which prevailed.

In Table XXXV, details of temperature, relative humidity, and hours of sunlight are recorded for each period relevant to the experiment, from the date of germination to that upon which the time for planting-out had arrived.

TABLE XXXV

Period	Temperature ° F.					% Relative Humidity			Hours Sunlight	
	Mean	Maximum		Minimum		Average	Maximum	Minimum	Total	Average Daily
		Absol.	Mean	Absol.	Mean					
Feb. 3–18	64·8	72	67·5	58	62·2	85	96	70	19·9	1·2
,, 19–22	63·5	76	70·0	54	57·0	65	84	48	18·1	4·5
,, 23–Mar. 1 ...	60·5	70	67·3	50	53·6	70	88	52	26·5	3·8
Mar. 2–8	59·1	73	63·9	52	54·3	73	90	46	4·0	0·6
,, 9–15	63·5	76	67·9	56	59·1	71	86	45	11·0	1·6
,, 16–22	65·5	78	70·0	52	61·0	71	89	38	4·3	0·6
,, 23–29	72·4	99	90·1	48	54·7	62	91	20	45·0	6·4
,, 30–Apr. 5 ...	72·0	91	90·7	51	53·3	59	90	26	48·0	6·9

It has been demonstrated that the growth of tomato seedlings which had been deprived of their cotyledons within a period of 14 days after germination, was subsequently retarded, and that the degree of retardation was in inverse proportion to the period of time after germination at which the cotyledons had been removed. Further, seedlings so treated were at least partially restored to their normal rate of growth in height by the incorporation of excess phosphate with the soil in which they were potted after transference from the seed-box.

Soon after glasshouses are heated up for the propagation of tomato plants, pupæ of Leaf-miner which may be present in the soil beneath the staging begin to emerge. The eggs, which are inserted by the flies into the cotyledons of the seedlings, hatch within a short space of time, and the larvæ may destroy the tissues of the cotyledons well within a period of 11 days after germination of the seed.

Although additional injury is caused by the mining of the larvæ in the rough leaves, after they have ascended within the tissues of the stem, it is suggested that incorporation of extra amounts of mineral fertiliser, especially of superphosphate, with the soil used for potting-up, might lead to a reduction in the degree of this injury.

7. AZO-BENZENE AS A CONTROL FOR RED-SPIDER MITE

By W. H. READ

A discovery which promises to be of great importance to glasshouse growers was made by Prof. W. E. Blauvelt[1] of Cornell University, U.S.A., who found, when conducting tests with a dust containing azo-benzene, that the vapour of azobenzene was highly toxic to red-spider mite. Prof. Blauvelt has kindly supplied information on the methods employed in fumigating glasshouses with azobenzene in the United States where this chemical is being used by florists at a rate exceeding 100,000 lbs. per year. Its principle use in the United States was for the control of red-spider mite on roses and carnations and very little information was available regarding its use on tomatoes and cucumbers.

Two methods of fumigating with azobenzene were being used in the United States. In the first a paste, made by stirring a powder containing 70 per cent. azobenzene with a little water, is painted on some of the steam-heating pipes when cold, the ventilators closed and the steam circulated through the pipes to vaporise the azobenzene. The second method is to vaporise the azobenzene crystals with hot plates or lamps. Vaporisation of the chemical must be carried out slowly, a period of three hours is recommended, to avoid damage and it is also advised that the temperature should remain around 75° F. for the six-hour fumigation. A drop in temperature below 70° F. during fumigation is said to be likely to cause injury as is a sudden fall in temperature at the conclusion of the fumigation.

The quantity of azobenzene advised by Prof. Blauvelt is 1 lb. of distilled azobenzene (setting point 58° C.) per 57,000 cu. ft. or its equivalent if the 70 per cent. powder is employed.

In view of the importance of Prof. Blauvelt's discovery, laboratory and glasshouse experiments were commenced at Cheshunt to find if azobenzene could be employed for the control of red-psider mites on glasshouse crops in this country.

A brief description of the properties of azobenzene may be of interest. Azobenzene is an orange-red, crystalline solid, melting (when pure) at 68° C. and boiling at 295° C. It vaporises very slowly at ordinary temperatures, is insoluble in water but very soluble in many organic liquids and has a not-unpleasant smell.

Azobenzene is a substance which has been little employed in industry and supplies of technically pure azobenzene were unobtainable. This necessitated the purification of considerable quantities of crude azobenzene in the laboratory and for the majority of the glasshouse trials a product having a melting point of 60° C. was used. Purified azobenzene having a M.Pt. of 68° is being employed in laboratory investigations.

The question of the toxicity of azobenzene to man has been the subject of a review by Prof. Blauvelt[2], following rumours that it was dangerous to health. There is no evidence to support these rumours, but it is obviously desirable to adopt all reasonable precautions. Prolonged exposure to the vapour should be avoided and solutions of azobenzene in organic solvents such as acetone, which may be used when fumigating by spray-vaporisation methods, should not remain in contact with the skin but should be washed off with soap and water. Blauvelt advises as a precautionary measure the wearing of a "good dry felt pad respirator" when prolonged exposure to the vapour is unavoidable. More toxic products may be present in crude azobenzene but no determinations of the nature and quantities of impurities in samples of crude azobenzene have been made so far.

The experiments made in glasshouses at Cheshunt can be most conveniently divided into two groups according to the manner in which the azobenzene was vaporised. In the first experiments the azobenzene was vaporised by heating the required quantity with a lamp or on a hot plate. This method has a number of disadvantages. Electrically-heated hot plates would be impractical on the majority of nurseries since the necessary electric power is unavailable and, in any case, the cost of equipment would be very high. Suitable fuel-burning vaporising lamps were unobtainable. Furthermore the method suffers from certain technical difficulties which will be indicated later.

As an alternative method the azobenzene was vaporised by spraying a solution of azobenzene in a volatile solvent into the air of the glasshouse. This method will be described in greater detail later.

A complete account of all the experiments cannot be included in this report, but the following details have been selected as of importance; the main object of the tests was to gain a knowledge of factors which require more detailed laboratory investigations.

Heat—Vaporization experiments. Dosage and temperature effects.

These tests were conducted in a glasshouse of 1,500 c. ft. capacity and the azobenzene was heated with a spirit lamp so that the necessary quantity took between two and three hours to vaporise. One half of the house was planted with tomatoes (var. E.S.1) and mite-infested tomato

and carnation plants were placed in the other half. Unfortunately this house has no separate heating system, consequently temperatures could not be adjusted. The fumigations were therefore commenced at times when it was thought that the desired temperature range would be maintained. The duration of the fumigation period was six hours except where fumigations were commenced in the evening and the house ventilated at 8 a.m. the following morning.

Some of the pot plants used in each experiment were stood on sheets of paper so that the mites which lowered themselves on webs or fell from the plants could be collected and examined. Previous experiments had shown that some of the mites suspended themselves from webs or fell from the plants when exposed to azobenzene vapour—in this respect the effect on the mites of azobenzene vapour is similar to that of naphthalene vapour.

After the completion of the fumigations leaves were removed from some of the plants and the proportion of mites surviving after seven days recorded. In addition the fumigated, mite-infested plants were retained and examined 14 days after being fumigated. The necessity for delaying assessment of the results until seven days after fumigation is due to the slow killing of mites by azobenzene vapour.

It was found that many mites which were motionless or only feebly motile immediately after fumigation with a lethal dose regained the ability of subnormal movement within 24 hours and frequently did not die until several days after exposure to azobenzene vapour. The period of survival appeared to be greater at low temperatures. The period of survival at 60° F. as shown by the ability of mites to make feeble leg movements when touched, was about five days.

That this effect was not due to the presence of azobenzene or toxic substances derived therefrom, on the fumigated leaves was shown by transferring some fumigated mites from the leaves on which they were fumigated to untreated leaves. After two days 82 per cent. of the mites remaining on the fumigated leaf and 55 per cent. of the transferred mites showed movements when touched. After five days 7 per cent. of the untransferred mites and 0 per cent. of the transferred mites were capable of movement. The low figure for transferred mites may be due to injuries during transference since some fumigated mites were difficult to be removed from the leaves.

Results

Analysis of the data obtained in these trials showed that plant injury was greatly affected by temperature. In one experiment in which a dosage of 0·6 ozs./1,000 cu. ft. was used, an unexpected bright period caused the temperature in the house to rise to an average of 88° F. for four hours after the fumigation commenced and no damage was caused to the plants. When the same dosage was used and the temperature fell from 70° at the start to 65° in the first two hours severe injury to tomatoes resulted and carnation blooms were also injured. In both these experiments 100 per cent. of adult mites on leaves removed for examination and collected from the paper on which the plants were stood, were killed. No live mites were present on the fumigated plants when examined after a fortnight, and eggs and resting stages appeared to have been killed.

No damage to tomatoes and carnations resulted from the vaporisation of ·3 oz./1,000 cu. ft. in experiments in which the temperature remained, with slight variations only, above 70° F. for the period of the fumigation. This dosage gave percentage kills varying from 78 to 100 per cent. of the adult mites. High winds with resulting increased loss of vapour from the house may be responsible for the incomplete kill of mites in several of these tests. The same dosage caused injury to tomatoes in a test where the temperature dropped rapidly from 76° F. to 63° F. soon after the start of the fumigation. The damage in this case was confined to one corner of the house.

Experiments in which a dosage of 0·25 oz./1,000 cu. ft. was used showed this quantity was insufficient to kill all adult mites. No damage was caused in any of the experiments at this dosage where the azobenzene was vaporised slowly.

The Effect of Rapid Volatalisation by Heat

Some experiments were conducted in which azobenzene was vaporised rapidly with an electric hot plate and it was found that even where doses as low as ·18 ozs./1,000 cu. ft. were used the upper foliage of the tomato plants in the immediate vicinity of the hot plate were damaged. This is attributed to the local high concentration of azobenzene vapour and is a factor of considerable importance. If vaporising lamps are used in tomato houses they will of necessity be close to plants and unless a considerable number of lamps are employed the rate of vaporisation from individual lamps will have to be high in order to obtain the necessary concentration of vapour.

Spray—Vaporization Experiments.

As an alternative to the vaporisation of azobenzene by heating, the effect of spraying a solution of azobenzene in a volatile solvent into the air of glasshouses is being investigated. This process

will be referred to as a "spray-vaporisation" method since its object is to obtain the necessary concentration of azobenzene vapour by the vaporisation of the minute particles of azobenzene resulting from the evaporation of the solvent. The small particles of azobenzene initially form an aerosol but rapidly become vaporised. In these experiments the solution of azobenzene was discharged from a standard paint spray gun operating with compressed air. The air pressure employed was 45 lbs. to a sq. in. and for most experiments the rate of discharge of the solution was adjusted to 3 fl. ozs. per minute. Care was necessary when employing this method in tomato houses to prevent the mist from the gun coming into direct contact with plants since it was found this caused injury, and the rate of discharge had to be regulated to avoid this. A higher rate of discharge was possible when fumigating carnations as the spray could be discharged above the plants.

Acetone was used as the solvent in most of these trials since previous work had shown that its vapour was not injurious to plants at relatively high concentrations. Solutions containing 20 per cent. w./v. of azobenzene proved satisfactory and were employed in some trials, in others 12·5 per cent. w./v. solutions were employed. Other solvents may be found more satisfactory and the best combination of solvent and amount of azobenzene in the solvent have not yet been determined in laboratory tests.

Experiments in a number of glasshouses were made when conditions were expected to enable a temperature of 70° F. to be maintained for six hours after the azobenzene solution had been discharged.

Results of Experiments

The experiments with the spray-vaporisation of azobenzene which could be carried out were limited through lack of time and must be regarded as preliminary investigations only. This method of vaporising azobenzene appeared to be less liable to cause injury to plants than vaporising azobenzene by heat. Laboratory experiments are necessary to prove if this is so and to determine the reason.

On no occasion during the experiments was damage caused to tomatoes and carnations when 20 per cent. w./v. or 12·5 per cent. w./v. solutions in acetone were discharged at the equivalent of 0·3 oz. azobenzene per 1,000 cu. ft., even though in one test the temperature dropped from 70° F. at the commencement of the fumigation to 60° F. after one hour, and in another test where the same dosage was employed, the temperature remained between 61° F. and 59° F. throughout the period of fumigation.

Percentage mortalities of adult mites resulting from a dosage of 0·3 ozs. azobenzene per 1,000 cu. ft. were determined in the same way as in tests with heat vaporised azobenzene and varied from 83 to 100 per cent. The method of assessing results was not entirely satisfactory, however, for it is possible that mites which fall from the plants may be able to move from the papers on which the plants were stood. In one experiment, conducted in a house containing carnations grown in pots, where 0·3 azobenzene per 1,000 cu. ft. was employed, 85 per cent. of the adult females and 100 per cent. adult males remaining on the leaves were dead after seven days. All the mites collected from the papers died within seven days, but a considerable number of live adult female mites were found by the entomologist on grass growing in a number of pots in the house. These mites were active and able to lay eggs. Whilst it is possible that the mites may have been protected in this case from a lethal concentration of azobenzene by falling from plants into the grass, the possibility of mites leaving the papers cannot be overlooked.

The examination of carnations fumigated with 0·3/1,000 cu. ft. of azobenzene suggests that either almost complete control of all stages of mites is normally obtained or mites which fall from the plants fail to re-infest the plants.

Tests in which four times as much acetone as would be used in fumigating with 0·3 oz. azobenzene per 1,000 cu. ft. by spray-vaporisation from a 12·5 per cent. solution, showed that the acetone alone was without effect on the mites. No damage to tomatoes or carnations was caused by this amount of acetone.

Discussion

The preliminary results obtained in glasshouse experiments show that azobenzene is a very promising substance for the control of red-spider mites on glasshouse crops. Many factors require further investigation in the laboratory and no general recommendation can be made until many more glasshouse trials have been made.

The spray-vaporisation method of fumigating with azobenzene seems to have certain advantages over the volatalisation of azobenzene by heat. Acetone has been found a satisfactory solvent for preparing solutions of azobenzene for spray-vaporisation but other solvents may prove more suitable.

The amount of acetone vapour in the air of a glasshouse treated by spraying sufficient of a 12·5 per cent. w./v. solution of azobenzene in acetone to give a dosage of 0·5 oz. azobenzene per 1,000 c. ft. is well below the explosive limit.

[1] W. E. Blauvelt, New York State Flower Growers, 1945, Bull. 2, p. 6; 1946, Bull. 7, p. 15.
[2] W. E. Blauvelt, The Florists Exchange, 1946, **107**, 15; 1947, **108**, 47.

8. AN EXPERIMENT ON THE CONTROL OF ROOT-KNOT EELWORM (HETERODERA MARIONI (CORNU) GOODEY) WITH D.D.

By W. H. READ

A material named D.D. has been mentioned in the technical press on several occasions in connection with the control of eelworm in soil. This product, which is a liquid and is said to consist of approximately equal parts of 1 : 3 dichloropropene and 1 : 2 dichloropropane, is applied by injection into the soil at sufficiently close intervals for the vapours to diffuse throughout the mass.

The early investigations with D.D. were conducted in America by Carter in 1943 and since then considerable work has been done both in that country and elsewhere to determine the value of D.D. as a control for root-infesting eelworms. The results of these investigations have shown that D.D. is highly toxic to eelworms, including the tomato root-knot eelworm ("Club") *Heterodera marioni*.

The conditions under which many of their trials were made differed from the conditions which would be encountered were D.D. employed for the control of either root-knot eelworm or the potato eelworm (*Heterodera Rostochiensis*) in tomato houses in this country.

D.D. has a strong, unpleasant smell and the question of the "tainting" of tomato fruits by the uptake of small quantities of one or more constituents of the mixture from the soil, required investigation and information was required regarding the possibility of damage to plants grown in treated soils.

A quantity of D.D. mixture was obtained through the kindness of Messrs. Technical Products, Ltd. Unfortunately it was not available until too late for replicated trials on commercial nurseries but trials were made in experimental houses at the Research Station where there were a number of plots heavily infested with the root-knot eelworm.

The soil in two plots was treated with D.D. by inserting 3·8 ml. amounts of D.D. at depths of 8 ins. and at intervals of 12 ins. The holes were closed by pressing in with the heel immediately after the insertion of the D.D. The surface of the soil was consolidated by light treading and was then lightly damped. The surface of the soil in the two untreated control plots was similarly consolidated and moistened.

The plots were planted with tomatoes (variety Potentate) in two stages, half of each plot being planted 14 days and the other half 20 days after the test plots had been treated with D.D. Normal cultural practices were adopted and the first fruits to ripen on plants in the treated plots were carefully tasted by a number of people to ascertain whether any unusual flavour had been acquired by these fruits. The roots of the plants were carefully removed at the end of the season, 29 weeks after planting and examined.

Experimental Data

Date of Treatment	March 3rd.
Spacing of Injections	1 ft. intervals.
Depth of Injections	8 ins.
Dosage	3·8 ml./injection—equivalent to 400 lbs. D.D. per acre.
Nature of Soil	Medium loam. Soil Temperature 64° F. at 2 ins. deep and 60° at 6 ins. deep, when treated.

Results

There was no indication of injury to tomato plants placed in the ground two weeks after planting.

No unusual flavour could be detected in the fruits from plants grown in the treated soil.

A high degree of control of the root-knot eelworm (*Heterodera marioni*) was obtained by the treatment with D.D. This is best illustrated by the photographs of representative samples of the roots from plants grown in treated and untreated soils. Complete eradication or the pest was not obtained and as is seen by the few galls which are present on the roots from plants grown in the treated soils.

Roots from untreated plots.

Roots from plots treated with D.D.

Discussion

The results of this trial indicate that D.D. is a very promising material for the control of root-knot eelworm in tomato soils. A great deal more experimental work is required to determine the best conditions of use, dosage rates, etc., in wide varieties of soil. Under the conditions of the test tomatoes could be planted without injury 14 days after treating the soil, and although this period might have to be increased for heavy, retentive soils, there should be no difficulty in allowing sufficient time between treatment of the soil and planting, on most tomato nurseries.

IV. CHEMICAL INVESTIGATIONS

By O. OWEN

1. General

The outstanding problem of this year's advisory work was the contamination of soils on two commercial nurseries by chlorate.

In one case the damage to plants was extensive but not severe and was seen on tomatoes and to some extent on cucumbers. Other plants on the nursery did not appear to be affected. As is usual in extensive chlorate injury distribution of the poison in the soil was very irregular and it seemed probable that injury to the cucumbers was attributable to contamination of the potting soil from a path treated with sodium chlorate weed killer. Contamination of the soil in the tomato houses could not be traced to the same source and is still unexplained. It so happened that the tomato houses were sited on a slope and much of the contaminant was washed out by heavy watering.

In the other case the injury was both acute and extensive; in fact, the extent of the damage to economic plants was greater than we had ever observed before. In some areas young plants wilted and shed their older leaves within 24 hours of planting. Indeed, the concentration of the poison in the soil was so high that the majority of plants died before showing the characteristic mottle associated with mild chlorate injury. Repeated treatment with lime sulphur and successive heavy waterings made it possible for some plants to make some growth during the late season, but in parts of the areas definitely affected the plants refused to grow during the whole season and in consequence there was a serious reduction in crop. An interesting sequel to the poisoning was that much of the fruit was "blotchy." This may well have been due to the leaching of potash inevitable with such heavy watering as was practised.

2. The Effects of Sulphur on the Reaction and Lime Content of a Tomato Soil

For the 1945 crop sulphur was dug in to one of the plots at the rate of two tons per acre. As was reported last year, this dressing reduced the carbonate content of the soil by 0·9 per cent. and the pH value from 7.79 to 7.14. To see how long these lower values would persist neither lime nor sulphur was added for the 1946 crop. During this year the pH value fluctuated considerably, falling to 7.0 and showing a peak of 7·76. By December 31st it had fallen to 7·17 which is not appreciably different from the value on January 1st. During the same period the carbonate value varied but not so widely, and at the end of the year was 1·62 per cent. compared with 1·5 at the beginning. The difference is not appreciable. It is concluded therefore that the heavy dressing of sulphur has in fact effected a permanent reduction in lime content and reaction value.

The dressing of sulphuric acid given to another plot for 1945 was equivalent in amount to approximately half a ton of sulphur per acre. This produced a decided reduction in both pH and carbonate values immediately after application and again it was a matter of interest as to how long the reduced values would persist. During 1946 pH values varied considerably, 6·68 and 7·77 being extreme figures. Over the whole year the value changed from 6·98 on January 1st to 7·26 on December 31st. Lime, however, increased quite appreciably, being 1·5 at first and eventually being 2·48.

3. The Use of "Green" Wood for Staging

By O. OWEN

Loss of colour in varying degree occurred very extensively on leaflets of young tomato plants on a commercial nursery during the propagating season. The condition varied from a slight pale green to a yellowish green area at the apical end of the leaflet. The seedlings had been normal in the boxes and the condition reported developed after they had been potted up and stood on staging. None of the young plants was so seriously affected that they could not be planted out. Once in the soil in the borders the plants made normal growth and showed no ill-effects.

It was considered on the nursery in question that the condition was due to the staging. This was new and described as "green" chestnut. The effect on the plants was attributed to acetic acid in the wood. Actually the wood was oak and although the appearance of the leaflets might be due to acetic acid vapour, similar effects are in fact produced by quite a number of compounds. However, as the use of "green" wood might be necessary on other nurseries it was necessary to examine the problem. Consequently wood actually used for the staging and "green" wood from another source was used in a series of experiments. In the first series the wood as received was used as a platform for a number of young plants in 60 pots which were covered with a bell jar. In this way any

volatile matter generated by the wood would be retained round the foliage of the plants. In no case was any effect observed which in any way resembled that which was responsible for the experiment.

In the second series the foregoing experiment was repeated with the difference that the wood was newly planed lest any weathering might have reduced or impaired the generation of volatile compounds. Again the results were negative.

In both the above experiments some of the young plants were allowed to grow until their roots had spread out of the pots and were in actual contact with the wood.

In a third series young plants were stood on a glass plate covered to a depth of about 1 in. with sawdust made from the suspected or other new woods and again all were covered with a bell jar. As before, no ill-effects were observed.

Experiments carried out with acetic acid were not entirely successful in that although similar effects can be caused by this compound they are not exactly the same because effective concentrations produce a scorch at times.

It was concluded that the wood was not the factor responsible for the condition. It seems probable that the condition was due to incorrect balance of nutrients in the propagating soil. It is possible to reproduce the effect almost exactly by the addition of an excess of soluble carbon compounds to the soil. This upsets the carbon/nitrogen ratio and a very mild deficiency of nitrogen occurs.

4. The Use of 2 : 3 : 5—Triiodobenzoic Acid to induce Flowering in Tomatoes

By O. OWEN

American workers have shown that the application of this compound to the soil causes the formation of flower trusses in place of vegetative shoots in tomato plants. A number of experiments with plants at various stages of development were carried out to determine how far the results would apply under our conditions. Applying the compound at rates between 0·3 and 3 mgms. per 100 grms. of soil caused no effects whatsoever. Used at rates of 30 mgms. and over per 100 grms. of soil invariably caused acute and permanent distortion of the plants. In no case, however, were flower shoots produced instead of vegetative shoots.

5. Trace Element Deficiencies

By O. OWEN

These experiments have been extended this year to carnations, and were confined to the variety King Cardinal. Cuttings were propagated in sand and as rooting developed they were watered as necessary with a dilute solution of complete nutrient. When the plants were about 6 ins. high they were transferred to large glazed pots which were to be their permanent quarters and the different solutions applied at regular intervals. The nutrient solutions were made up as complete and complete without one each of the following— potassium, nitrogen, phosphorus, boron, iron, manganese, magnesium, calcium. Growth was somewhat slow during the first four weeks and at the end of that period there was little difference in the appearance of the plants irrespective of treatment. At the end of six weeks, however, signs of nutritional disorder were manifest in plants which were receiving no potassium, no calcium, no nitrogen, and no phosphorus respectively. Of these the most pronounced effects were those caused by the omission of calcium, namely lack of colour, the development of translucent areas, and tip scorch.

At this stage deficiency signs were not sufficiently acute nor sufficiently differentiated to serve as a pattern for diagnostic purposes.

Six weeks later, however, all the plants were showing quite definite signs but unfortunately the position was confused by the fact that on all plants irrespective of treatment some of the lower leaves were dying. General indications at this time were as follows:—

No Potassium.—General retardation of growth; definite retardation of bud formation; pale foliage and some translucent areas in leaves.

No Nitrogen.—Definite stunting and a generally pale colour; some tip scorch and dark red areas near the tips ; oldest leaves showed quite large reddish purple areas; leaves of intermediate age showing red to purple areas at base; decided retardation of bud formation.

No Phosphorus.—Colour generally fairly good; reduction in number of shoots; some of the older leaves showing reddish-purple areas as for no nitrogen; small translucent areas on new growth.

No Boron.—General stunting sufficiently acute to produce a bushy effect; extensive translucent areas particularly near the midribs; odd reddish-purple areas; some tip and marginal scorch and a fair amount of leaf distortion; definite retardation of bud formation.

No Iron.—In the main colour as good as in plants receiving complete nutrient but leaves quite definitely narrower; slight tip scorch on a few leaves; no restriction on shoot or bud formation apparent.

No Magnesium.—Pale colour; restriction in shoot formation; acute loss of colour near tips of some leaves; some translucent areas; no apparent effect on bud formation.

No Manganese.—To all intents and purposes the same as plants receiving complete nutrient.

No Calcium.—The most acutely affected of all. Considerable loss of colour generally; extensive translucent areas; practically every leaf tip scorched; very decided retardation of bud formation.

Under commercial conditions deficiencies in chrysanthemums have been encountered for the first time.

In one case chrysanthemums were growing in borders in which tomatoes had previously been suspected of magnesium deficiency. At the flowering period leaves developed a definite discolouration consisting of pale green or yellow areas which appeared intervenally and in acute cases spread to the mid rib. The general effect was reminiscent of magnesium deficiency symptoms in tomato leaves. In no case was the condition really acute as is shown in the left leaf in the photograph. Tissue analysis of the foliage indicated that the condition was due to magnesium deficiency. Preliminary experiments suggest that the condition can be corrected by spraying with a solution of Epsom Salts on the lines already established for tomatoes.

On another nursery where chrysanthemums followed tomatoes in borders, discolouration of a different type appeared. Here the yellowing started quite definitely at the edges and there was appreciable marginal scorch. Suspected potassium deficiency was confirmed by tissue tests. This case is symptomatic of what is happening in many nursery soils where the drain on potash by continuous tomato cropping is such that even the comparatively high reserves built up before the War are giving out.

6. The Availability of Nitrogen in some Organic Fertilisers

By O. OWEN and D. W. ROGERS

Long experience has established organic sources of nitrogen such as dried blood and hoof and horn as valuable manurial ingredients for tomatoes under glass. Usually the view is held that the nitrogen in hoof and horn becomes available to plants relatively slowly and is therefore effective over comparatively long periods. The nitrogen in dried blood on the other hand is considered as being available fairly quickly and its effects of relatively short duration. Other materials such as fish and whale meals and meat and bone tankage are regarded as being intermediate in quickness of effect. As a result it is customary to apply hoof and horn meal as part of the base dressing before planting so that a continuous supply of nitrogen is available to the plants for the first weeks after planting in the borders. Dried blood is usually included in top dressings where an early effect is required and these dressings are repeated at intervals of 10 to 14 days. Fish and whale meals and meat and bone tankage are used either as base or top dressings according to the experience of the individual grower. The nitrogen in bone meal has been regarded as the most resistant to decomposition while guano has been considered as a source of quickly available nitrogen.

During the war years all of these materials have been at some time or another either not available or in very short supply. Consequently, it has frequently been necessary to substitute one or more for others. Particularly has this been the case in the replacement of hoof and horn by dried blood. This might well have resulted in the production of excessively soft plants in the early season whereas in fact this did not happen. It is therefore a matter of some interest to have some more precise information as to the rate at which some of these materials decompose in soil. Accordingly experiments have been started to determine the rate at which nitrate is produced from them under controlled conditions.

During the time available it has only been possible to work with one particular soil, and so it does not necessarily follow that the results now reported will be reproducible with other soils. The full details of the technique will be described elsewhere but the principles of the method adopted were as follows:—

Amounts of the fertilisers weighed so that each contained the same amount of total nitrogen were mixed intimately with soil and placed in glazed earthenware jars so that losses of moisture were reduced to a minimum and so that there was reasonable access to air. At intervals the whole of the contents of each pot were turned out, mixed thoroughly, and a representative sample taken for a determination of the nitrate. This was repeated at intervals for a period of 60 to 70 days.

Mild magnesium deficiency in chrysanthemums.

The results for dried blood and hoof and horn are shown in Graph V and for some of the other fertilisers in Graph VI. In both figures the scales are the same so that the results are strictly comparable.

From Graph V it will be seen that there is comparatively little difference between the amounts of nitrate formed from dried blood and hoof and horn. In both cases nitrification does not begin until after five days, and in the case of dried blood there is definite denitrification immediately after mixing. At the end of the period of test it is interesting to note that of the nitrogen added to the soil 58 per cent. has been nitrified in the case of the dried blood and 50 per cent. in the case of hoof and horn.

From Graph VI it will be seen that guano yielded most nitrate and it is calculated that nitrification accounted for 77 per cent. of the nitrogen added. Of this over 80 per cent. of the nitrate was produced in the first five days. Hoof meal, fish meal, and whole meal all reduced nitrate content immediately after mixing. During the whole period percentages of nitrogen converted into nitrate were bone meal 50, hoof meal 35, fish meal 51, and whale meal 46.

The results for bone meal were somwhat unexpected, as of the nitrate produced over 70 per cent. was generated in the first five days and except for guano this is the highest value recorded in such a short time. This is not in keeping with the accepted views of the role of bone meal in fertiliser practice. The obvious possibility was that the phosphate introduced in the bone meal stimulated the organisms responsible for nitrification. To test this superphosphate in equivalent amount to the bone meal was added with dried blood to soil with the following results:—

TABLE XXXVI

Added to Soil	Nitrate-nitrogen in p.p.m.			
	After 2 Days	After 9 Days	After 15 Days	After 22 Days
Dried Blood alone	11	9	13	23
Dried Blood plus Superphosphate ...	10	12	24	31
Bone Meal alone	12	22	22	31

Although the dried blood plus superphosphate had produced the same concentration of nitrate at the end of 22 days the production of nitrate in the intervening period favoured the bone meal, so that the phosphate may not be entirely responsible for the behaviour of bone meal.

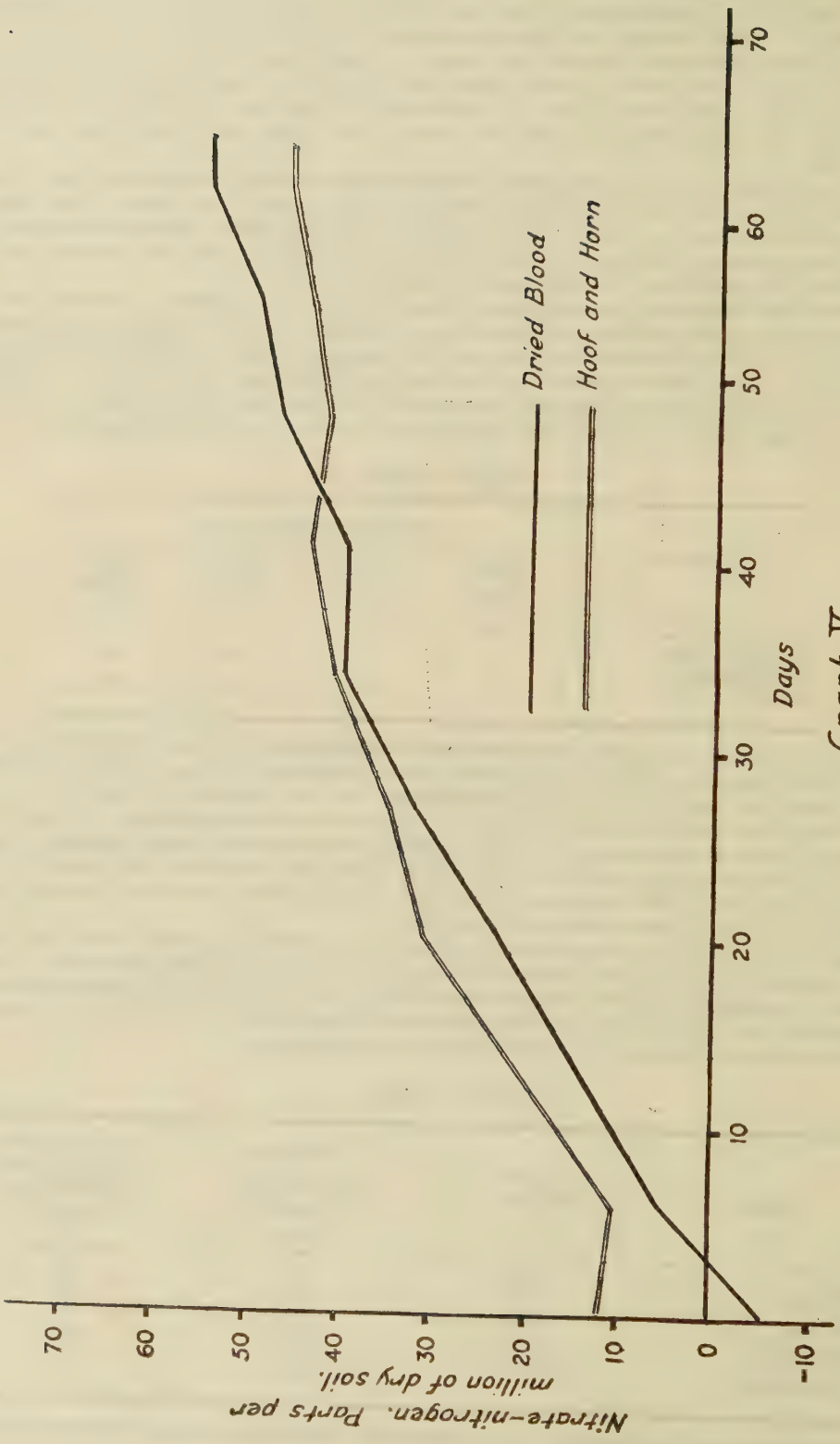
At the end of the period in Graphs V and VI, water was added to all the pots so that the soil was wetted. In no case was the amount so added sufficient to increase the water content by more than 2½ per cent., so there was no possibility of leaching. Samples taken after this showed a reduction in nitrate in every case. This confirms a conclusion already made in earlier reports that wetting does in fact reduce the nitrate content of these soils.

Of further interest is the comparison of nitrogen converted into nitrate with the value determined by chemical analysis of the availability of nitrogen in some of these materials. This method depends on the proportion of the total nitrogen which is soluble in neutral permanganate. Values for this quantity are shown in the following table, which also includes the actual proportion of the total nitrogen converted into actual nitrate during the experiment.

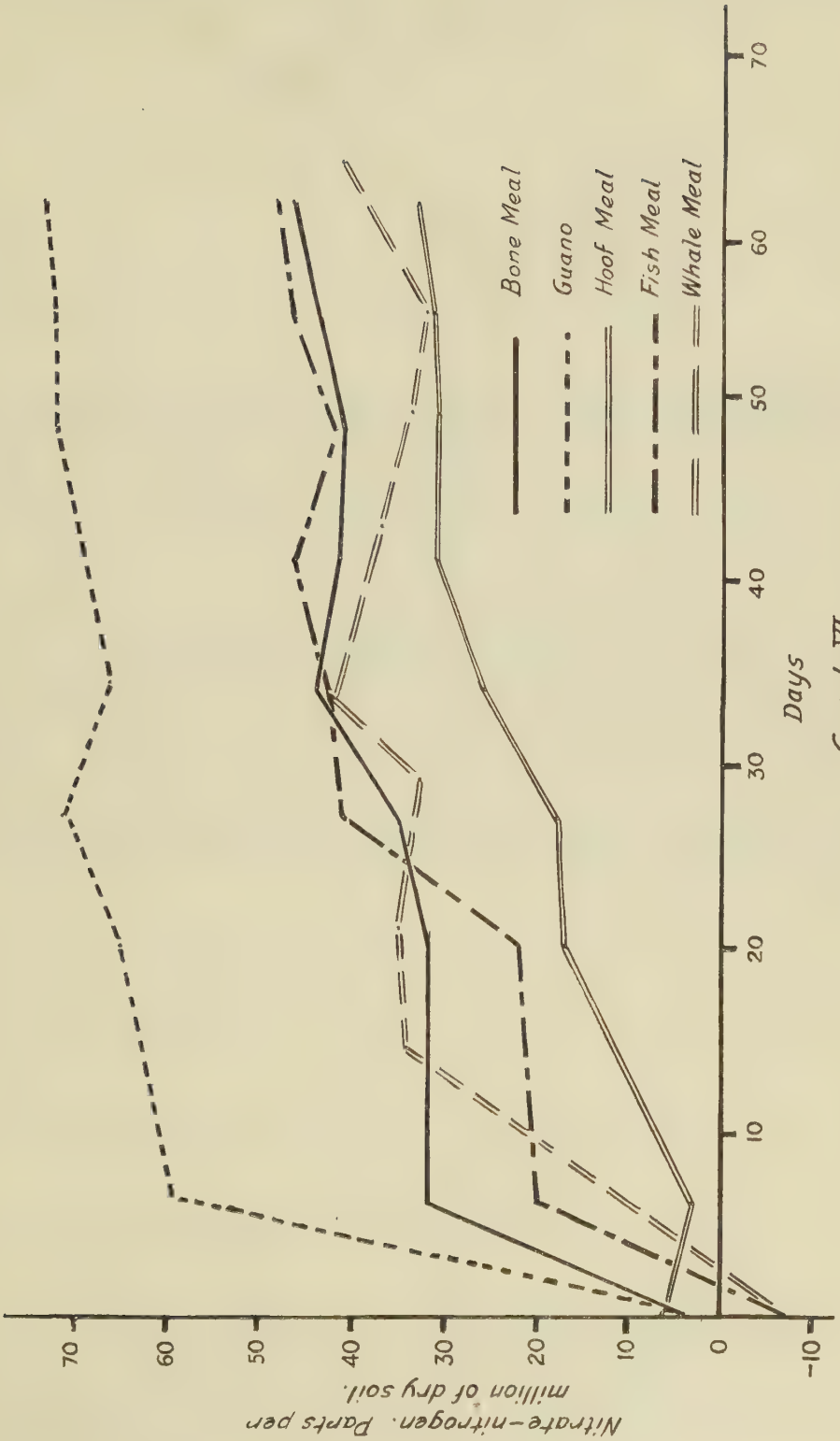
TABLE XXXVII

Fertiliser	Total Nitrogen %	Percentage of Total Nitrogen converted into Nitrate	"Availability" as measured by Nitrogen Soluble in Neutral Permanganate %
Guano	9·60	77	66
Bone Meal	3·01	50	40
Hoof Meal	12·09	35	75
Whale Meal	5·41	46	57
Dried Blood	13·33	58	83
Hoof and Horn	13·13	50	75

It is clear that the "availability" as determined by solubility in neutral permanganate provides no reliable guide to actual decomposition under our conditions.


Nitrate-nitrogen. Parts per million of dry soil.
70
60
50
40
30
20
10
0
-10
10
20
30
40
50
60
70
Days
Dried Blood
Hoof and Horn

Graph V


Nitrate-nitrogen. Parts per million of dry soil.
70
60
50
40
30
20
10
0
-10
10
20
30
40
50
60
70
Days
Bone Meal
Guano
Hoof Meal
Fish Meal
Whale Meal

Graph VI

In another experiment of shorter duration some leather products were included. In this case tests were only continued for 22 days and the results are shown in the following table:—

Material	Nitrate-nitrogen p.p.m. produced in 22 Days
Chamois Meal A	1
Chamois Meal B	–7
Leather Shavings	–3
Acidulated Leather Meal ...	5
Treated Leather	–4
Fish Guano	40
Meat and Bone Tankage ...	35
Dried Blood	23

Both the samples of chamois leather meal appeared to be attractive. As will be seen, nitrification for A had not started and in the case of B some denitrification had occurred. These results were quite unexpected as this type of product has almost a legendary value as a fertiliser for market garden work. No particular merit was claimed for the leather shavings and the figure found suggests that there is none. The acidulated leather meal was submitted to us for examination in the course of our advisory work and on the basis of the figure shown it would not appear to have any great value. The treated leather was a processed material which was claimed to be valuable presumably on the basis of a high figure for availability estimated by the solubility in neutral permanganate. The present result hardly bears out the claims made for it. The results for the fish guano and meat and bone tankage were as might have been expected, except that one would hesitate to put them above dried blood in the matter of nitrate production.

In conclusion we would mention one other consideration which may be important. This concerns the temperatures at which the experiments were carried out. All the pots containing soil as controls and the soil/fertiliser mixtures were kept together in a bench in the laboratory and temperature records were kept throughout. During most of the time temperatures ranged between 50 and 60° F. During July, however, temperatures did on occasion rise above 70° F. It is unlikely that temperatures in the different pots were sensibly different and it is probable that fluctuations occurred to the same extent in all of them. It is possible, nevertheless, that the different organisms responsible for converting complex organic compounds into nitrates have different optimum temperatures and temperature variations may have produced selective effects. This should be borne in mind when the results reported are being considered.

APPENDIX "A"

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APPENDIX "B"

MANURIAL TREATMENT IN TOMATO EXPERIMENTS

(Except plots in Appendix C)

(1) **Lime**

All houses with the exception of Plots 5 and 6 in house 4 and house 5 received hydrated lime at the rate of 10 cwts. per acre.

(2) **Base Dressing**

Houses 1 to 5 and 7 to 12 were steamed and received sulphate or muriate of potash at the rate of half ton per acre only.

(3) **Top Dressings**

Sulphate of Potash.—All houses received a first top dressing of sulphate of potash at the rate of 5 cwts. per acre excepting those receiving muritae of potash in houses 7, 8, and 9.

Fertiliser Mixture.—All houses except house 4, plots 1, 2, 7, and 8 received 5 cwts. per acre of a wartime mixture every 14 days at discretion.

APPENDIX "C"

MANURES APPLIED IN PLOTS 1–3 AND 10–12 IN TOMATO HOUSE 4

Plot	Title	Base Manure in Lbs. per sq. yd.				*Top-dressing in Lbs. per sq. yd.		
		Lime	Stable Manure	Super-phos-phate	Sulphate of Potash	Super-phos-phate	Sulphate of Ammonia	Sulphate of Potash
1	Complete Artificials (I) without Nitrogen	1·0	—	0·4	0·1	0·5	—	0·2
2	Unmanured	1·0	—	—	—	—	—	—
3	Complete Artificials	1·0	—	0·4	0·1	0·5	0·2	0·2
10	Complete Artificials with Dung	1·0	7	0·4	0·1	0·5	0·2	0·2
11	Complete Artificials without Phosphate	1·0	—	—	0·1	—	0·2	0·2
12	Complete Artificials without Potash	1·0	—	0·4	—	0·5	0·2	—

** The Top-dressing was applied in eight equal instalments.*

APPENDIX "D"

DATES OF CULTURAL OPERATIONS, 1945–1946

Crop	Sown	Potted into 60's	Potted into 32's	Planted out in Borders	First top Dressing	First Fruit Picked	Last Feed Applied	Last Fruit Picked
Tomatoes	Jan. 8, 1946	Feb. 11, 1946	—	Mar. 27, 1946	May 5, 1946	May 25, 1946	Aug. 21, 1946	Oct. 25, 1946
Cucumbers	Feb. 1, 1946	—	Feb. 18, 1946	Mar. 3, 1946	May 14, 1946	Apr. 8, 1946	Aug. 20, 1946	Oct. 1, 1946

APPENDIX "E"

METEOROLOGICAL RECORDS, 1946

Month	Air Temperatures						Grass Temperatures			Rainfall			Mean Soil Temperatures		Hygrometer				Bright Sunshine		Barometer
	Mean		Absolute Maximum		Absolute Minimum		Av. Min.	Absolute Minimum		Total Precipitation	No. of Days Ptn.	Greatest Fall			Dry Bulb	Depres. of Wet Bulb	Relative Humi'ty %	Dew Point	Total No. of Hours	Daily Average	
	Max.	Min.	Temp.	Date	Temp.	Date		Temp.	Date			Amt.	Date	1 ft.	2 ft.						
	°F.	°F.	°F.		°F.		°F.	°F.		Ins.		Ins.		°F.	°F.	°F.	°F.		°F.			Ins.
JANUARY ...	43·3	32·9	55·0	10th, 11th, 12th	19·0	19th	27·5	13·0	19th	1·61	9	0·39	9th	38·1	40·4	37·7	1·3	87·3	34·1	49·4	1·59	30·09
FEBRUARY ...	49·0	37·8	56·0	7th	20·0	27th	33·6	13·0	27th	2·73	16	0·53	8th	41·8	42·6	44·0	1·5	87·9	40·5	67·6	2·41	29·92
MARCH ...	47·4	34·6	69·0	29th, 30th	21·0	9th	30·8	18·0	9th	1·45	6	0·41	21st	39·6	40·7	42·9	2·5	80·9	37·2	78·9	2·55	29·94
APRIL	62·6	40·1	79·0	4th	27·0	10th	34·4	20·0	10th	1·64	9	0·77	29th	48·6	48·0	53·9	3·8	78·1	46·6	186·0	6·20	30·04
MAY	61·5	42·9	69·0	12th, 23rd, 30th	30·0	14th	38·7	25·0	14th	2·75	14	1·03	14th	52·6	51·8	53·3	2·9	81·9	47·6	174·5	5·63	29·87
JUNE	66·8	49·3	78·0	23rd	41·0	6th	45·3	34·0	6th	2·51	19	0·34	8th	59·7	57·5	60·3	3·7	78·5	53·3	166·1	5·54	29·93
JULY	73·9	52·7	86·0	2nd	43·0	16th	48·3	38·0	16th	3·05	8	1·38	26th	64·3	62·3	65·7	4·2	78·2	58·2	215·3	6·95	29·97
AUGUST ...	69·6	52·1	82·0	4th	41·0	17th	47·9	36·0	17th	3·46	17	1·11	9th	60·1	59·9	61·5	2·4	86·4	57·1	163·8	5·28	29·75
SEPTEMBER ...	65·2	50·8	77·0	27th	43·0	15th	46·0	37·0	15th, 20th	3·62	18	0·61	20th	56·7	57·1	58·0	1·4	91·3	55·4	96·6	3·22	29·85
OCTOBER ...	56·8	44·2	71·0	2nd	28·0	28th	38·2	22·0	28th	1·66	10	0·62	22nd	52·0	53·9	51·8	1·9	86·8	47·8	78·3	2·53	30·07
NOVEMBER ...	51·7	41·8	63·0	4th	32·0	7th, 22nd	36·4	25·0	7th, 22nd	3·72	20	0·62	14th	46·9	48·6	47·6	0·7	94·9	46·1	38·6	1·29	29·69
DECEMBER ...	41·6	30·4	50·0	1st	16·0	20th	25·1	9·0	20th	1·86	17	0·26	11th	37·9	41·9	36·7	0·9	89·7	33·9	65·0	2·10	29·92

Total rain for year = 30·06 inches. No. of days precipitation = 163. Total Bright Sunshine for year = 1,380·1 hours.